Geo F Rhodes

Electrical Engineering

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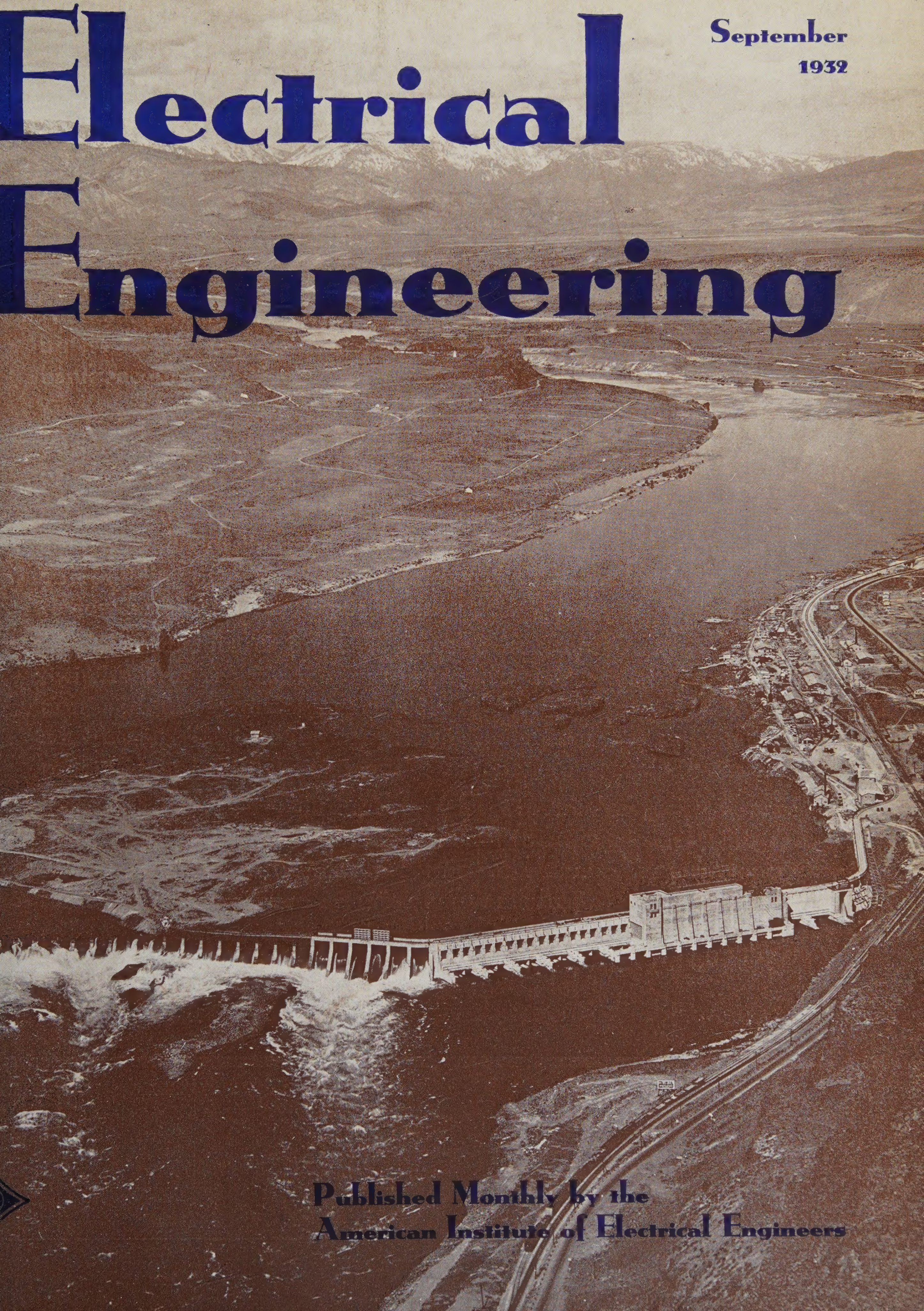

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Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
Baltimore, Md.	October 10-13, 1932	District Meeting	(Closed)
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	Oct. 23, 1932
Schenectady, N. Y.	May 1933	District Meeting	Feb. 1933
Chicago, Ill	June 25-30, 1933	Summer Convention	March 25, 1933

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Assn. for the Advancement of Science, annual convention	Atlantic City, N. J.	Dec. 27–31	C. F. Roos, Permanent Secy., Smithsonian Inst., Washington, D. C.
American Gas Association, annual convention	Atlantic City, N. J.	Oct. 10	C. W. Berghorn, Secy., Mfrs. Sec., 420 Lexington Ave., New York, N. Y.
American Physical Society	Chicago, Ill.	Nov. 25–26	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Physical Society	Pasadena, Calif.	Dec. 16–17	L. B. Loeb, Pacific Coast Secy., Univ. of California, Berkeley, Calif.
American Physical Society, annual meeting	Atlantic City, N. J.	Dec. 28–30	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Society of Civil Engineers, fall meeting	Atlantic City, N. J.	Oct. 5–8	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Society of Mech. Engrs., annual meeting	New York, N. Y.	Dec. 5–9	C. W. Rice, Secy., 29 W. 39th St., New York, N. Y.
American Welding Society, fall meeting	Buffalo, N. Y.	Oct. 3–7	M. M. Kelly, Secy., 33 West 39th St. New York, N. Y.
Electrical Insulation Committee, N. R. C., annual meeting	Baltimore, Md.	Oct. 10–11	Dr. J. B. Whitehead, Johns Hopkins Univ., Baltimore, Md.
Empire State Gas and Electric Assn.	Saranac Lake, N. Y.	Sept. 22–23	C. H. B. Chapin, Grand Central Terminal, New York, N. Y.
Illuminating Engineering Society	Swampscott, Mass.	Sept 27–29	E. H. Hobbie, 29 W. 39th St., New York, N. Y.
International Assn. of Electragists	Kansas City, Mo.	Oct. 10–12	L. W. Davis, 420 Lexington Ave., New York, N. Y.
National Council State Boards of Engineering Examiners, annual convention	New York, N. Y.	Sept. 27-Oct. 1	T. Keith Legare, Secy., P. O. Box 264, Columbia, S. C.
National Safety Council, annual safety congress	Washington, D. C.	Oct. 3–7	W. J. McCarter, Secy., The Cleveland Railway Co., Cleveland, Ohio
New England Waterworks Assn., annual meeting	Springfield, Mass.	Sept. 27–30	Frank J. Gifford, Secy., 715 Tremont Temple, Boston, Mass.

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This Month—

Front Cover

Rock Island hydroelectric plant of the Puget Sound Power & Light Company, Wash., the first electric power development on the famous Columbia River, and the first large low head installation on the Pacific Coast. This plant is situated east of the Cascade Mountains about 13 miles downstream from Wenatchee; its initial capacity is 60,000 kw. See p. 654–9 of this issue. Stone & Webster Photo

—Turn to Next Page

PRESIDENT HOOVER recently appointed 6 prominent engineers to serve as the engineering advisory board to the Reconstruction Finance Corporation. *p. 665–666*

EXPERIMENTS on the electric arc using pure iron electrodes in an inert atmosphere reveal information that may require a modification in the basic conception of the electric arc discharge. *p. 624–627*

A REPORT on proposed American standard electrical definitions is now available in pamphlet form. The report represents 3 years of effort on the part of a sectional committee of the A.I.E.E. standards committee, and contains 208 pages. *p. 670*

IF EXPERIMENTS on a 1,000-hp. locomotive with commutatorless motors confirm the results of laboratory tests, electric railway practise may be revolutionized. Mercury arc rectifiers replace not only the motor commutators but much expensive control apparatus as well. *p. 650–654*

BUT few operating difficulties have been experienced in 3 years of operation on the electrified portion of the Cascade division of the Great Northern Railway, which includes the famous 7.79-mile Cascade tunnel. Operating statistics show great savings in both time and expense in favor of electrical operation versus steam. *p. 627–633*

COMMITTEES are hard at work to assure those who will attend the Baltimore meeting, October 10–13, 1932, a profitable and enjoyable visit. Inspection trips have been arranged to some of the city's many attractions and to nearby points. The program includes also several sports events and special features for the ladies. *p. 663–665.* Technical papers to be presented deal chiefly with communication and power cables, and a major hydroelectric development. *p. 659–662*

A GREAT DEAL of engineering time and effort is being devoted to reducing lightning disturbances on electric power systems. Results of some recent studies on the protection of distribution systems are covered in a group of 3 articles in this issue. Tests show that interconnecting the primary lightning arrester ground with the grounded secondary neutral provides greater protection than is obtained with present conventional arrester connections. *p. 633–647*

CORRECTION. Through an error in the author's original manuscript, eq. 11 on p. 486 of the July issue of ELECTRICAL ENGINEERING is stated incorrectly; the correct form is $S = \frac{1}{2}\pi^2 E_0 \cdot \frac{c}{L} \cdot \frac{A}{L}$

MEMBERS of the Institute continue to express themselves upon various subjects through the medium of letters to the Editor. A selection from those received recently may be found in this issue. *p. 667–670*

OFFICERS AND COMMITTEES chosen to serve the Institute for the year 1932–33 were announced recently. *p. 678–681*

DESIGNED to provide primarily for the comfort and convenience of its occupants, the 33-story office building of the Philadelphia (Pa.) Saving Fund Society is said to contain the most modern electrical and mechanical equipment. The total connected electric light and power load is nearly 5,000 kw. *p. 621–624*

A *Report on*

Telemetering, Supervisory Control, and Associated Communication Circuits

Prepared by a joint subcommittee of the A.I.E.E.*

THIS REPORT summarizes information as to telemetering and supervisory control systems in use today or commercially available in the United States, and includes a detailed discussion of the communication circuits suitable for such purposes. The form of the report is designed to make it convenient for a prospective or existing user of telemetering or supervisory control equipment to obtain information concerning the specific equipment in which he may be interested.

The tabulations in the telemetering and supervisory control sections enable the prospective user having in mind a certain requirement, for example the telemetering of a-c watts, to determine immediately the systems available for the purpose. The characteristics of each of the systems suitable for the telemetering of a-c watts may then be examined in detail with the aid of the table and consideration narrowed to a few systems concerning which additional information may be desired from the manufacturer in order to determine upon the one best suited to the conditions involved. The types of communication circuits suitable for operation with each telemetering or supervisory control system are indicated in the tables.

The information in the report has been arranged in 3 main sections:

I. Telemetering—including a tabulation of the characteristics of each system.

II. Supervisory Control—including a tabulation similar to that for telemetering.

III. Communication circuits—information concerning their use for Telemetering and Supervisory Control Systems.

Much of the information in this report has been contributed by the manufacturers. Information as to communication circuits has been obtained from the communication companies and other available sources.

No attempt has been made to include data covering the field operation and maintenance of the various telemetering and supervisory control systems.

On this and the following 7 pages is given essentially the full text of an hitherto unpublished report concerning the present status of development of proven devices as used in telemetering and supervisory control services. The text of the report as published herewith was prepared by D. W. Taylor, chairman of the A.I.E.E. automatic stations committee, and E. I. Green, member of the joint subcommittee, to cover the subjects embraced by the original report, but of necessity eliminating the extensive and detailed tabulations of that report. However, in parts I and II of the accompanying article is given a comprehensive digest of the corresponding parts of the original report including an insight into the content and construction of the tabulations which form the major portion of those parts of the original report. Part III of the original report, presenting for the first time in published form a comprehensive discussion of the communication circuits and facilities involved in telemetering and supervisory control, is given here in its entirety. That the report in question may be kept up to date and improved in value, the committees involved earnestly solicit an interchange of information with all parties operating telemetering and supervisory control equipment. —Editors.

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*Essentially full text (excepting extensive tabulations) of a report jointly prepared by the committees listed below and presented at the A.I.E.E. annual summer convention at Cleveland, Ohio, June 20–24, 1932. *A few lithographed copies of the full report are available at Institute headquarters for distribution to members vitally interested.*

Joint subcommittee—C. F. Craig, *chairman;* A. E. Anderson, P. A. Borden, E. D. Doyle, E. I. Green, R. J. Wensley, F. Zogbaum.

Committee on automatic stations—D. W. Taylor, *chairman;* F. F. Ambuhl, A. E. Anderson, L. D. Bale, C. F. Craig, John Fies, A. M. Garrett, Joseph Hellenthal, C. A. Mayo, I. E. Moulrop, M. E. Reagan, O. J. Rotty, Garland Stamper, L. J. Turley, F. Zogbaum.

Committee on instruments and measurements—E. J. Rutan, *chairman;* H. S. Baker, R. D. Bean, O. J. Bliss, P. A. Borden, H B. Brooks, A. L. Cook, E. D. Doyle, W. W. Eberhardt, Marion Eppley, W. N. Goodwin, Jr., I. F. Kinnard, O. A. Knopp, A. E. Knowlton, H. C. Koenig, W. B. Kouwenhoven, F. A. Laws, E. S. Lee, J. B. Lunsford, Paul MacGahan, R. T. Pierce, W. J. Shackelton, H. L. Thomson, H. M. Turner.

I—Telemetering

HEREIN *telemetering* is considered to be the indicating, recording, or integrating of a quantity at a remote point by electrical translating means. Electrical or mechanical quantities normally are involved, although there are other miscellaneous applications for telemetering.

Types and Characteristics of Systems

The numerous systems and combinations of equipment used for telemetering may be classified broadly on the basis of the translating means employed. Such classification has been recommended to the Institute for adoption, and includes: (1) Current, (2) Frequency, (3) Impulse, (4) Position, and (5) Voltage.

This report endeavors to present a uniform analysis of existing systems. The characteristics have been detailed under items which past engineering experience indicates to be essential to bring out the design, installation, and performance features. In order to cover the entire field, it has seemed desirable to present the information in tabular form. The user ordinarily will be concerned only with a limited number of systems, and the arrangement of the information is such that he easily can fix upon the system or systems which appear best to meet his requirements.

The different telemetering systems which have been included in the table are as follows:

	Name of System	Manufacturer
1.	Midworth distant repeater	J. G. Biddle Co.
2.	Long distance transmitting and recording system	The Bristol Co.
3.	Remote type transmitting and recording system	Brown Instrument Co.
4.	TM flow meter	Builders Iron Foundry
5.	MacCreedy fluid level indicator	J. H. Bunnell & Co.
6.	Long distance recorder	Esterline-Angus Co.
7.	"Elinco" remote indicating system	Electric Indicator Corp.
8.	Magnetic impulse telemeter	General Electric Co.
9.	Rectified current telemeter	General Electric Co.
10.	Torque balance telemeter	General Electric Co.
11.	Selsyn equipment	General Electric Co.
12.	Demand metering system	General Electric Co.
13.	Distant dial system	General Electric Co.
14.	Long distance outfit	W. & L. E. Gurley
15.	Telemetric gage	James S. Kennedy
16.	Micromax thermal converter telemeter	Leeds & Northrup Co.
17.	Micromax potentiometer transmitter telemeter	Leeds & Northrup Co.
18.	Micromax voltage multiplier telemeter	Leeds & Northrup Co.
19.	Micromax current balance telemeter	Leeds & Northrup Co.
20.	Micromax wheatstone bridge telemeter	Leeds & Northrup Co.
21.	Stevens Type P recorders and indicators	Leupold, Volpel & Co.
22.	Stevens Type G recorders and indicators	Leupold, Volpel & Co.
23.	Telemco gage	Pittsburgh Equitable Meter Co.
24.	Conductance meter	Republic Flow Meters Co.
25.	Fluid meter register	Simplex Valve & Meter Co.
26.	Tanner type telemeter	Wallace & Tiernan Products Co.
27.	Wallace type telemeter	Wallace & Tiernan Products Co.
28.	Electronic current balance system	Westinghouse Elec. & Mfg. Co.
29.	Current balance system	Westinghouse Elec. & Mfg. Co.
30.	Low rate impulse system	Westinghouse Elec. & Mfg. Co.
31.	High rate impulse system	Westinghouse Elec. & Mfg. Co.
32.	Rectox system	Westinghouse Elec. & Mfg. Co.
33.	Position indicator	Westinghouse Elec. & Mfg. Co.

The characteristics of the above systems are listed in the tables under the following classification.

General
1. Manufacturer
2. Trade name
3. Method of operation (translating means)

Character of Indications Provided

4. Quantities measured
   Electrical Quantities
   a. Amperes, a-c
   b. Amperes, d-c
   c. Ampere-hours, d-c
   d. Frequency
   e. Integrated demand
   f. Power factor
   g. Reactive voltamperes
   h. Reactive voltampere hours
   i. Totalized watts, a-c
   j. Totalized watthours, a-c
   k. Volts, a-c
   l. Volts, d-c
   m. Voltampere hours
   n. Voltage phase angle difference
   o. Watts, a-c
   p. Watthours, a-c
   Other Quantities
   a. Levels
   b. Positions
   c. Pressures
   d. Quantities of flow
   e. Rates of flow
   f. Temperatures
5. Continuous or step-by-step indication

Performance

6. Speed of response—seconds
   a. Transmitter—zero to full scale reading
   b. Lag from transmitter to receiver
   c. Total
7. Estimate of maximum probable error under normal operating conditions (per cent of full scale)
8. Power requirements
   a. Transmitter
   b. Receiver
9. Will correct indication be given after:
   a. Interruption in power supply
   b. Temporary disconnection of line circuit

Characteristics Affecting Line Transmission

10. Frequency—cycles per second
11. Maximum number of impulses per minute
12. Is neutral or polar relay employed
13. Maximum allowable loop resistance—ohms
14. Minimum allowable insulation resistance—megohms
15. Number of conductors
16. Possibility of using ground as conductor
17. Possibility of using conductors exposed to high potentials
18. Possibility of using superposed circuits as conductors:
    a. Simplexed
    b. Composited
    c. Carrier

Interference and Protection Features

19. Normal line current
20. Maximum line current on short circuit
21. Maximum open circuit voltage
    a. Between wires
    b. To ground
22. Is additional equipment required to limit noise on adjacent telephone circuits
23. Description of system

Power Supply at High Voltage Stations

The use of station batteries for the supplying of power telemetering transmitters located in high voltage stations is generally inadvisable. Station batteries usually are connected to an extensive network of local control wires having a high electrical capacitance to ground, and subject to contact or leakage to ground. For reliability a separate battery or other insulated source should be used. This battery should be charged from a separate, ungrounded generator or rectifier; and if alternating current be used it should be supplied from a separate ungrounded transformer fed from the low voltage station bus which should be grounded.

II—Supervisory Control

SUPERVISORY control provides, by electrical means and over a relatively small number of conductors, for the selective control and supervision of several remotely located units of equipment or apparatus. It is the purpose of this report to present to the prospective user information that will enable him to select the equipment which will provide the desired operating features and at the same time function satisfactorily in connection with available communication circuits.

Applications

At present, supervisory control systems have their greatest field of application in power systems, where they are used for the automatic operation of apparatus in generating, switching, transformer, or conversion stations. These systems are employed also in water, gas, oil, and other industries for the operation of pumping stations, and the control of levels and pressures of gases, liquids, etc. Supervisory control is applicable in general to the remote control and supervision of any device that may be operated electrically. A partial list of such devices is included in Section 26 (Automatic Stations) of A.I.E.E. Standards.

In addition to the control features provided, indications of the position of different devices such as switch positions, governor settings, gate and valve openings, and of such conditions as bearing and winding temperatures, pressures, levels, synchronization, may be secured. Arrangements for the telemetering of various quantities may be incorporated in control systems.

Performance Features

Features generally desirable in supervisory control equipment may be summarized as:

1. The highest degree of reliability and speed obtainable in the correct selection of units, with due regard for economy.
2. Safeguarding of a selected unit against incorrect operation and the correct operation of a unit as quickly after its selection as is consistent with safety.
3. A visual and/or audible indication at the control point of changes occurring in the position of any of the supervised units.
4. Automatic notification at the control point of the occurrence of major troubles such as open, shorted, or grounded conductors, and the loss of operating potential in a distant station, that may cause the supervisory control system to become inoperative.
5. Safeguarding against false operation in the event of failure of any portion of the supervisory control equipment to function.

Capacity—Power Supply

Some of the supervisory control equipments have structural features which impose more or less definite physical limitations as to the number of units that may be supervised from one system. Other equipments may be used to supervise any number of units that may be installed. Some stations may be of such size and importance as to justify more than one supervisory control installation.

The comments under telemetering relating to power supply practises in high voltage stations apply with equal force to supervisory control. In addition, special care should be exercised where supervisory wiring is connected to units located in a high voltage structure.

In the full report the supervisory control systems have been tabulated in a manner somewhat similar to the arrangement for telemetering systems. The following systems have been included:

	Name of System	Manufacturer
1.	Selectrol system	General Control Corp.
2.	Synchronous selector system	General Electric Co.
3.	2-Wire synchronous selector system	General Electric Co.
4.	2-Wire code selector system	General Electric Co.
5.	Code synchronous selector system	General Electric Co.
6.	Audible selector system	General Electric Co.
7.	Audible indicating system	General Electric Co.
8.	Synchronous visual system	Westinghouse Elec. & Mfg. Co.
9.	Visicode radial system	Westinghouse Elec. & Mfg. Co.
10.	Visicode series system	Westinghouse Elec. & Mfg. Co.
11.	Visicode parallel system	Westinghouse Elec. & Mfg. Co.
12.	Audicode system	Westinghouse Elec. & Mfg. Co.
13.	Televox system	Westinghouse Elec. & Mfg. Co.
14.	Polaricode system	Westinghouse Elec. & Mfg. Co.
15.	Polaricode radial parallel system	Westinghouse Elec. & Mfg. Co.

Characteristics of the supervisory control devices covered by the report are tabulated therein, the tables embracing the following items:

General

1. Manufacturer
2. Trade name
3. Method of selection
4. Method of checking selection
5. Method of operation
6. Method of indication

Characteristics of System

7. Number of units
   a. Maximum recommended for one system
   b. Normal physical limitation
8. Maximum number of stations recommended for parallel operation over one group of communication circuits. (See item 20)
9. Power requirements
   a. Dispatching station
   b. Distant station

10. Time required to select and check
    a. 10th unit
    b. 20th unit
11. Having selected unit, can it be operated repeatedly without again performing selecting operation
12. Is automatic indication given to dispatcher
    a. Line open
    b. Line short
    c. Line ground
13. Can telephone conversation be carried over same communication circuit, intermittent or continuous
14. Is selective telemetering possible over same communication circuits
15. Is remote manual synchronization possible over same communication circuits

Characteristics Affecting Line Transmission

16. Maximum number impulses per sec
17. Is neutral or polar relay used
18. Maximum allowable loop resistance
19. Minimum allowable insulation resistance
20. Number of conductors
21. Possibility of using ground as a conductor
22. Possibility of using Superposed circuit as conductor
    a. Simplex
    b. Composite
    c. Carrier
23. Can system operate through insulating transformers

Interference and Protective Features

24. Normal line current
25. Maximum line current on short circuit
26. Maximum line volts open circuit
    a. Between wires
    b. To ground
27. How is system protected from electrostatic and electromagnetic induction when exposed to high potential circuits
28. Is additional equipment required to limit noise in adjacent telephone circuits
29. Description of system

III—Communication Circuits

TELEMETERING and supervisory control systems may be operated over different types of communication circuits. It is not practicable to set down rules which will definitely determine the type of circuit to be used in a given case. The choice will depend upon the characteristics of the equipment, the available types of circuits, the operating distance, cost factors, and other circumstances. The transmission and engineering considerations involved in the selection are discussed in the following paragraphs.

Line Signals—Translating Means

The systems described involve the transmission of the following types of signals:

1. D-c signals representing voltage or current, which change in accordance with the quantity to be measured.
2. D-c impulse signals, ranging in frequency from one impulse per minute to 15 impulses per sec.
3. Power frequencies, usually 60 cycles.
4. Frequencies in the voice range and above.

Only a limited use of frequencies in the voice range or above is being made in telemetering and supervisory control systems. The following discussion therefore is concerned primarily with circuits for the transmission of low frequency and d-c signals. The problems involved in the transmission of such signals over line circuits are similar in many respects to those encountered in d-c telegraph transmission and the same engineering considerations frequently apply.

Telemetering systems ordinarily transmit in one direction only, whereas supervisory control systems commonly require successive transmissions in opposite directions.

Circuit Characteristics

Circuits for use with telemetering or supervisory control systems may be leased or may be owned by

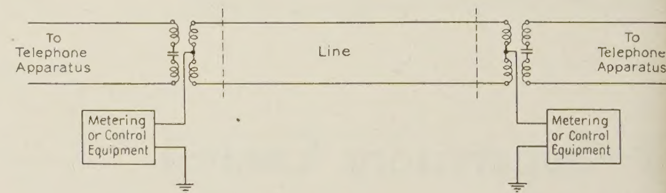

Fig. 1. Grounded low frequency circuit derived from simplexed telephone circuit

the user of the equipment. Both cable and open wire facilities are employed for these services, cable being in more general use. The line characteristics that may affect the operating range of low frequency systems are principally the linear resistance, to a lesser extent the leakage conductance (or insulation resistance), and occasionally the linear capacity or inductance.

The gage of cable most commonly used is No. 19 A.W.G., although relatively short lengths of 22, 24, or 26 gage cable frequently are employed in cities.

The gages of open wire commonly employed by the communication companies are 165-mil (No. 8 B.W.G.), 128-mil (No. 10 N.B.S.G.), and 104-mil (No. 12 N.B.S.G.), which coincide closely with those frequently used by the electric utilities and other industries; namely, 162-mil (No. 6 A.W.G.), 128.5-mil (No. 8 A.W.G.), and 101.9-mil (No. 10 A.W.G.).

The insulation resistance of cable circuits ordinarily is so high that it is not an important factor in the operation of telemetering and supervisory control systems. The insulation values obtained on open wire circuits in general are very much lower than those for cable circuits. Consequently, leakage frequently is the limiting factor in determining the range over which telemetering and supervisory control systems may be operated on open wire facilities. The leakage conductance varies over wide limits, depending chiefly upon weather conditions and the type and maintenance of the line, and to a smaller extent upon the insulators employed. Since the leakage in dry weather is negligible compared to that in wet weather, it is common practise to engineer systems on the basis of wet weather leakage values. For the purpose of determining the approximate range and accuracy of telemetering and control systems, it appears convenient to employ a single leakage value which may be considered to be representative for any open wire circuit. On this basis, the

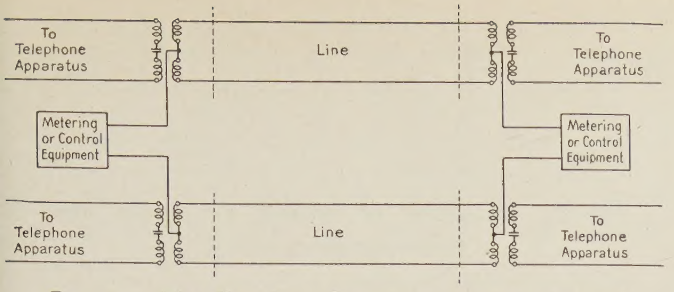

Fig. 2. Metallic low frequency circuit derived from simplexed telephone circuits

value of wet weather leakage conductance between one wire and ground may be taken as 5 micromhos per mile (0.20 megohm-mile). It is thought that on the average this value will not be exceeded on more than about one day out of a hundred and then only for a part of the day, although individual sections of the country may vary materially in this respect. The wet weather leakage conductance between wires probably will not be more than 2.5 micromhos per mile.

For determining the effect of uniformly distributed leakage conductance upon the accuracy of a d-c telemetering system, the percentage error usually may be taken as equal to 50 times the ratio of loop resistance in ohms to total insulation resistance in ohms.

The telemetering and control systems described require from 2 to 6 conductors, but since 2-conductor systems predominate, this discussion is directed primarily toward such circuits. The principles involved may be extended readily to systems requiring 3 or more conductors.

Circuits may be divided into 2 classes: metallic circuits in which a metallic conducting path is employed throughout, and grounded circuits in which the ground is used as one side. For many applications metallic circuits constitute a more desirable transmission medium than grounded circuits. However, the latter are satisfactory in many cases and ordinarily can be obtained at a low cost.

The simplest forms of circuits which may be used are: a circuit consisting of two conductors, and a circuit consisting of a single conductor and ground. More complicated arrangements are encountered when it is desired to superpose the telemetering or supervisory control channel on a circuit which also is used for telephone purposes. Such superposition is accomplished by simplexing or compositing.

Simplex Arrangements

The simplex method, illustrated in Fig. 1 as applied to the derivation of a grounded circuit, is based upon the principle of balance. If the telephone circuit is perfectly balanced there will be no net emf or current produced in either the telephone circuit or the derived simplex circuit by signals being transmitted over the other. The use of two telephone circuits to derive a single metallic low frequency circuit is shown in Fig. 2.

If a telephone pair is simplexed it cannot be used as a part of a phantom circuit. However, a phantom may be created from 2 pairs of conductors in the usual manner, and the phantom may be simplexed so as to give one grounded low frequency circuit over the four wires in parallel.

Simplexing connects the line conductors in parallel for the low frequency circuit. Circuit resistance thus is reduced correspondingly, but its linear leakage and capacity are increased.

Composite Arrangements

In superposing a low frequency circuit on a telephone circuit by compositing, use is made of frequency discrimination. The use of terminal composite equipment to derive 2 grounded low frequency circuits from a single telephone circuit is illustrated in Fig. 3 whereas Fig. 4 shows a single metallic low frequency circuit derived in a similar manner. The composite terminal equipment may be considered as consisting of a high-pass filter which freely transmits the telephone currents while attenuating the low frequency currents, and a low-pass filter which passes the low frequencies and attenuates the telephone frequencies. The low frequency band provided by the composite set extends roughly to 75 cycles, while the high frequency band extends upward from about 135 cycles.

Considerations Affecting Superposition

Transmission considerations involved in the use of simplexed or composited circuits for telemetering and supervisory control purposes are similar in general to those which apply in d-c telegraph transmission. For the longer open wire circuits it frequently will be desirable to composite rather than to simplex, because of the smaller leakage values obtained with composited circuits. Also, for the same reason

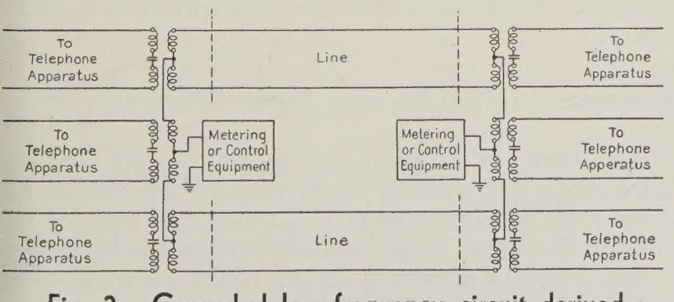

Fig. 3. Grounded low frequency circuit derived from simplexed phantom circuit

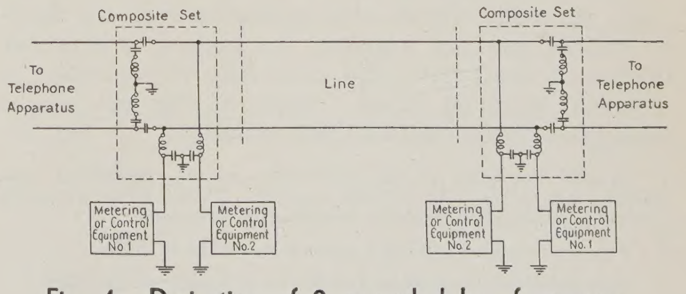

Fig. 4. Derivation of 2 grounded low frequency circuits from composited telephone circuit

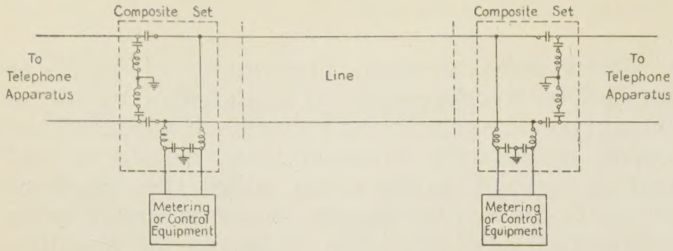

Fig. 5. Derivation of metallic low frequency circuit from composited telephone circuit

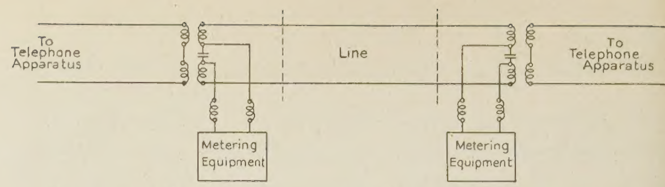

Fig. 6. Derivation of metallic d-c circuit from single telephone circuit

a composited open wire physical circuit normally is to be preferred to a composited open wire phantom.

Superposition frequently is accomplished not at the terminals of the telemetering or supervisory control system, but at some intermediate point, a simple metallic or grounded circuit being used from that point to the system terminal. The low frequency circuit may, of course, be superposed on several different telephone circuits in different parts of its length.

The circuit lengths for which superposition may be considered, ordinarily will be in excess of 1 or 2 miles.

Common Circuits

In some instances where a single metallic telephone circuit is available a suitable circuit arrangement will permit the use of this circuit also as a metallic low frequency circuit. In such cases the principal problem frequently is that of transmitting the telephone ringing current and the telemetering or control current without mutual interference. An arrangement employed for the derivation of a metallic circuit for a d-c telemetering system from a metallic telephone circuit is shown in Fig. 5. In this case the low frequency ringing (16 or 20 cycles) is applied to ground.

When several metallic circuits are desired between the same two terminals it is possible under certain conditions to use a single metallic conducting path as a common return, thus effecting an economy in the number of separate metallic paths required. This plan usually is feasible only for short distances where the circuit resistance is small in comparison with that of the terminals. It has been used successfully for systems employing d-c impulse signals.

Maintenance and Interference Protection

Since telemetering and supervisory control services generally are of vital importance in the fields in which they are applied, the highest practicable degree of continuity and reliability of operation is essential in most cases. Some of the procedures which have been found helpful include:

1. Special markings at the terminals, frames, protectors, test boards, etc., where the circuits appear. These serve to guard against possible interference or interruption to service.
2. Frequent routine tests and inspections of the facilities.
3. Arrangements for prompt location and clearing of troubles.
4. Arrangements for prompt restoration of service in the event of failure.

In operating telemetering and supervisory control systems in connection with different types of communication circuits, the application of certain requirements and limitations as to protection and interference conditions has been found desirable. These have been determined with a view to:

1. The provision of a satisfactory grade of telemetering and supervisory control service.
2. The avoidance of possible hazard to communication plant and personnel.
3. Avoidance of possible interference with communication services.

The requirements and limitations usually desirable for low frequency telemetering and supervisory control systems may be briefly summarized as:

a. The potential of a d-c supply under any conditions should not exceed 135 volts positive or negative between any conductor and ground. A potential of 270 volts may be employed between the 2 wires of a pair provided the midpoint of the applied voltage is grounded.

b. The potential of an a-c supply should not exceed 120 volts rms value between conductors or between any conductor and ground.

c. The maximum line current under any conditions should not exceed 0.35 amp. (In some types of loaded telephone conductors the maximum current is limited to 0.10 amp.)

d. Where there is a possibility of experiencing excessive ground potentials there should be no metallic connection between the line facilities and the high voltage station ground.

e. The apparatus should be provided with insulation adequate for the conditions under which it is to be used.

f. Not more than 50,000 noise units should be impressed on a paired metallic circuit. The noise impressed on any two wires not in the same pair, or between any wire and ground, should not exceed 10,000 noise units.

The communication companies generally are equipped to make noise measurements in cooperation with the user of the telemetering or supervisory control equipment. The above provisions agree, in general, with those observed in the operation of commercial telephone plant. When the user of telemetering or supervisory control equipment provides his own circuits it is sometimes possible to exceed these limitations without undesirable effects. Many of the systems now furnished by the various manufacturing companies are designed and constructed so as to conform to the provisions listed above.

Ground Potentials and Their Effects

An item of interest in metering and control services is the possible occurrence of differences between the ground potentials at the two ends of the circuit that may be of sufficient magnitude to cause appreciable interference in grounded circuits. Metallic circuits, on the contrary, are very rarely affected by ground potentials.

Differences in ground potentials ordinarily are small (not more than 10 volts). However, in a few locations in the United States the geological formation is such that varying differences of substantial magnitude in ground potential occur more or less continuously. Difficulties incident to this cause may be overcome by an arrangement known as a ground potential compensator, which will neutralize ground potential differences up to about +100 volts.

The effect of ground potentials on telemetering and control circuits depends, of course, upon the type of system. As a rule, the accuracy of telemetering systems which use a slowly varying direct voltage or current is affected by ground potentials. Consequently, metallic circuits generally are more desirable for such services. Systems employing d-c impulses, however, are much less susceptible in this respect, and usually are not affected by small differences in ground potentials. Therefore, grounded circuits may be used successfully in many applications of these latter types of systems.

Where several telemetering or supervisory control systems employing relay operation are to be used between the same terminals, an arrangement may be provided whereby a grounded channel is used for each system and a single auxiliary conductor is used to compensate for the effect of ground potentials in all systems.

Power Interference

In certain cases the transfer of energy from power circuits may introduce substantial alternating voltages and currents into circuits used for telemetering and supervisory control systems. If circuits closely parallel power line rights-of-way, special drainage and protection arrangements ordinarily will be required. In the more usual cases where signal circuits are less severely exposed to the power circuits, appreciable induction may be experienced during normal operation of the power system, but disturbances caused by abnormal occurrences on the power circuits, such as short circuits or grounds, will be of greater importance.

As in the case of differences in ground potential, metallic circuits are much less susceptible to power interference than are grounded circuits. Also, cable circuits are much less affected than open wire circuits. The amount of actual interference that such power induction may produce in telemetering and supervisory control systems depends, of course, upon the type of system employed and upon the magnitude of the effects present.

If a high voltage station ground or a nearby ground is used for grounded telemetering or supervisory control circuits these circuits are extremely susceptible to interference at times of abnormal conditions in the power system. This difficulty may be obviated by using an operating ground at an intermediate point (such as a telephone central office) some distance away from the high voltage station and employing a metallic circuit between that point and the high voltage station. This makes possible the use of a grounded circuit in sections not affected by disturbing potentials. The metallic circuit extending to the high voltage station must, of course, be insulated against the maximum potentials to which it may be subjected.

Operating Distances

The distance over which satisfactory operation may be secured with different types of telemetering and supervisory control systems depends both upon the design of the system and the character of the associated communication circuits. Ordinarily the manufacturer will indicate the approximate length of different types of circuits over which his equipment will yield a satisfactory performance. The scope of this report does not permit a statement of the maximum distances which may be spanned with each equipment as applied to each type of circuit. A few general observations, however, may be helpful.

For cable circuits, especially of the metallic type, the resistance usually is the principal factor in determining the operating range. With open wire circuits, the leakage frequently will be the controlling factor.

For systems having the higher speeds of transmitting impulses and for 60-cycle systems, especially when operated on simplexed or composited facilities, the effects of capacity and inductance in the communication circuit and in the compositing equipment will limit the length to much shorter values than those determined by resistance only.

In general, the positions of type telemetering systems are best suited to comparatively short distances, perhaps up to 5 miles.

The voltage and current types of telemetering systems cover, in general, a range of operating distances up to about 50 miles, with greater ranges

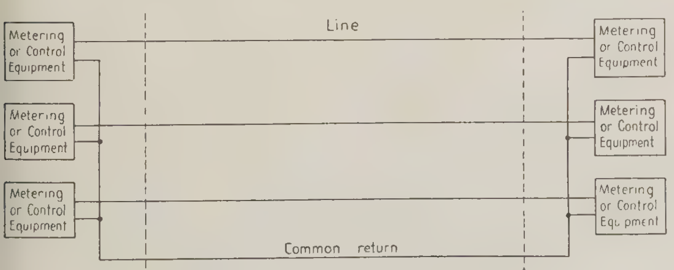

Fig. 7. Common return circuits

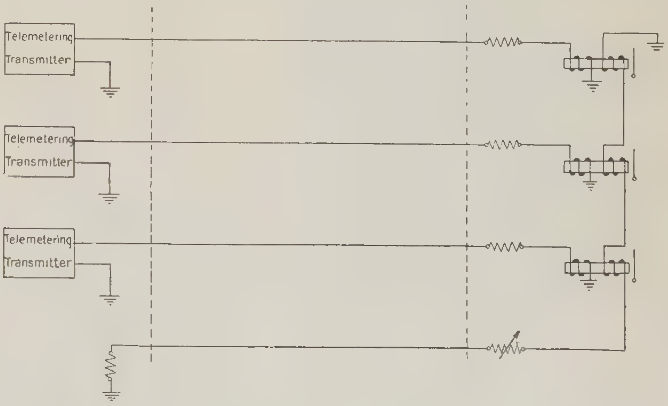

Fig. 8. Use of auxiliary conductor to compensate for ground potentials

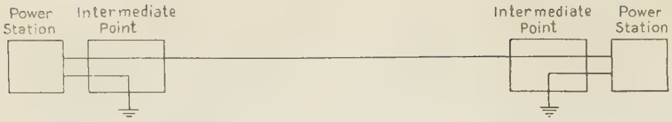

Fig. 9. Use of ground at intermediate points

feasible if simplexed cable circuits are used. The accuracy of these systems is affected appreciably by the leakage on open wire circuits. Metallic circuits are preferable for these systems; in fact, are essential for certain types.

Systems employing d-c impulses generally will span a maximum distance of from 50 to 250 miles or more. These systems are well adapted to the use of grounded channels, and their accuracy is not impaired by leakage conditions. For systems employing relay operation, greater distances usually may be spanned and superior operating results obtained by the use of polar operation or the equivalent instead of open-and-close operation.

Repeaters, for the most part, are unnecessary for the distances normally to be covered. In cases where it is desired to span unusually long distances, certain of the systems employing d-c impulse signals may be repeatered with ordinary telegraph repeaters. Also, repeaters employing equipment similar to the terminal equipment for some of the systems can be furnished by the manufacturers.

Circuits for Voice Frequency

The employment of signals in and above the voice frequency range is practicable for telemetering and supervisory control systems, although in most cases d-c or low frequency signals have been used. Some of the more important reasons for their usage are:

1. The employment of the voice frequency range for these purposes sacrifices its utility for telephone purposes.
2. The avoidance of interference with adjacent services is readily obtained by the utilization of the low frequencies.

The protection provisions desirable for telemetering and supervisory control systems employing frequencies in or above the voice range are somewhat the same as for low frequency systems. Where there is a possibility of interference with other services, the amount of energy usually is determined on the basis that the signaling energy should be comparable in its interfering effect with the normal voice currents.

IV—Conclusion

CONSIDERING the rapid advances in the art, a report of this nature, summarizing the present available information concerning telemetering and supervisory control systems, undoubtedly will be out of date in a relatively short time. It is hoped that frequent contributions will be received from users of telemetering and supervisory control equipment reporting their experiences with this apparatus so that this report may be supplemented from time to time as may seem desirable. The committee will be glad to assemble and correlate any comments of this nature that may be offered.

New Radio Tube Has Attractive Characteristics

PUTTING into apparently successful practical application the results of several independent research efforts, a new radio tube of interesting characteristics recently has been brought into the market. Known as the "Wunderlich Tube" this device is specially designed to serve as a high quality detector which combines full-wave rectification with a stage of audio amplification and provides also, all within one tube structure, the necessary voltage for the automatic control of sensitivity.

This new tube may be described as a coplanar grid tube in which grid rectification is obtained by employing 2 grids as the 2 anodes in a full-wave rectifier circuit, while these grids act in parallel to amplify the rectifier audio-frequency voltage, developed across the grid leak and grid condenser. The coplanar grid arrangement increases the power handling capacity of the grid-leak detector by giving greater output and also permitting the development of a voltage sufficient for automatic volume control purposes. The tube, of course, is distinctly different, both in construction and operation, from any of the other tubes now commercially available. It may be thought of as being an ordinary 3-electrode tube to which there has been added a second grid wound between the meshes at the usual grid, and developed in this instance to give a combined power detector and automatic volume control tube all in one. The detecting action is of the power-grid rectification type and, because of the coplanar arrangement, is able to deliver approximately twice as much undistorted output as can the ordinary triode type of grid rectifier. The volume control function is said to be performed without interfering in any way with the tube's primary function as a detector. Experiments seem to show that various control groupings can be arranged depending upon the characteristics of the particular circuit in which the tube is to be used.

The tube derives its name from Norman E. Wunderlich (A'27) of Chicago who, in cooperation with the Arcturus Radio Tube Company of Newark, N. J., has sponsored this first commercial coplanar grid type of vacuum tube to be placed upon the

American market. Some details pertaining to earlier efforts to develop a commercial type of coplanar grid tube are described in a paper, "A Study of the Output Power Obtained From Vacuum Tubes of Different Types," prepared by H. A. Pidgeon and J. O. McNally (A'26) which may be found on p. 266 of the February 1930 issue of the *Proceedings* of the Institute of Radio Engineers. Experimental and theoretical data supporting the contention that satisfactory power grid leak detection could be obtained were given in a paper, "Some Properties of Grid Leak Power Detection," prepared by F. E. Terman (A'23) associate professor of electrical engineering at Stanford University (California) and N. R. Morgan, then a graduate student at Stanford. This paper may be found in the December 1930 *Proceedings* of the I. R. E. The Wunderlich tube is the first commercial development to make use of these works and its evolution shows a serious attempt to develop a new tube capable of performing the functions for which present day receivers require 2 tubes.

"Nothing More Modern"

Electrical features of the Philadelphia Saving Fund Building include unusually high artificial illumination and complete air cooling and conditioning equipment, serving the entire building. The installation involves some unique designs and new applications of engineering materials. Owners, architects, and engineers have cooperated to secure a highly modern and practical structure.

By
C. D. FAWCETT
MEMBER A.I.E.E.
Associated with Howe and Lescaze, architects, and with H. Berkeley Hackett, consulting engineer, Philadelphia, Pa.

THE OLDEST savings bank in America, the Philadelphia (Pa.) Saving Fund Society, now is completing construction of a new 33-story bank and office building of the most modern functional design in America. With electrical and mechanical equipment selected to provide extensively for the comfort and convenience of its occupants, the building provides: elevator service 20 per cent faster than found in typical similar structures; for natural lighting efficiency, an outside wall area 65 per cent glass; for artificial lighting efficiency, an indirect system providing on all normal working planes an evenly diffused non-glare illumination of 19 ft-c; for exterior decorative effects, floodlighting near the ground, panel lighting near the roof, and a 27 × 120-ft neon sign on the roof; for the health and comfort of those in the building a complete recirculating air cooling and conditioning system, with full temperature and humidity control. Communication, alarm, and signal systems installed provide extensive facilities for telephone, radio, television, telegraph, stock ticker, telautograph, and synchronous time services. It is contemplated that the building will stand as a creditable monument to its owners, architects, and engineers, as an exemplification of their design slogan, "Nothing more modern."

Electric service to the building is supplied over 2 13.2-kv 3-phase 60-cycle circuits from independent sources. Two isolated sections of 13.2-kv bus and duplicate low voltage buses for power and light distribution are designed to operate normally with half of the entire building load on each of the 2 incoming high voltage feeders, with arrangements to interconnect automatically the 2 sections of the high voltage bus in the event of the failure of either feeder. The control facilities provide for manual rather than automatic restoration of normal service conditions after automatic transfer. Automatic interlocks on both the high voltage and low voltage circuit breakers prevent inadvertent paralleling of the 2 main service feeders. For extreme emergency conditions, full manual control may be established through a master release which makes the normal interlocking features inoperative. Since local system volt-

Fig. 1. Architect's drawing of "America's most modern" commercial structure, the 33-story bank and office building of the Philadelphia Saving Fund Society

Written especially for ELECTRICAL ENGINEERING by Mr. Fawcett, who in addition to his consulting activity is professor of electrical engineering at the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. *Not published in pamphlet form.*

age regulation is very good, no regulators were installed, 2 2.5 per cent taps above and below the normal 13.2-kv connection on each of the main transformers being supplied for possible future changes in nominal voltage values.

In the sub-basement substation, a 3-section semicircular duplex control board centralizes the control and metering for all circuits. The outside sections of the board carry triplex ammeters, respectively, for the power and the lighting feeders; the center section carries a dummy bus with a complete complement of pilot lights and control switches for operating all high voltage switches and the bus-tie and inter-bus emergency transfer switches, all necessary ammeters, wattmeters, power factor meters, totalizing graphic wattmeter, and graphic voltmeters for the power and light buses. The rear doors of the panel boards carry associated relays and test blocks, and also give access to the wiring. For all control wiring, multiple-conductor colored control cable is used, housed in accessible wire-ways placed at the top of the switchboard sections to protect against possible damage from flood waters.

Power for all service motors and elevators throughout the building is distributed over 3-wire 3-phase 60-cycle circuits at a nominal rating of 440 volts, whereas lighting equipment is fed from a nominal 199–115-volt 3-phase 4-wire 60-cycle grounded-neutral system. An auto-transformer is provided for the emergency transfer of energy between the light and power buses in the event of failure of one of the main transformers. Color identified wires and cables are used throughout the building for all low voltage feeders, subfeeders, and branch circuits for both light and power. Two special elevator feeders run the full height of the building, each with taps at the 20th floor for the low rise elevators, and at the 33rd floor for the high rise elevators. Each elevator feeder has copper capacity sufficient to serve all elevators, and switching facilities to provide for the transfer of any elevator to either feeder and hence to either of the building services. An excellent opportunity thus is provided for balancing power loads, for balancing power factor on the service feeders, and for inspection and maintenance requirements. In addition to the 2 elevator circuits there are 9 power feeders and 9 lighting feeders, and provisions for one spare feeder for replacing any defective lighting feeder. All circuits for the lighting system, including the transformers, have been designed and installed for a capacity approximately 50 per cent greater than the present connected load.

An interesting departure from common practise is presented in the design used in both low voltage bus feeders and in the corresponding distribution risers

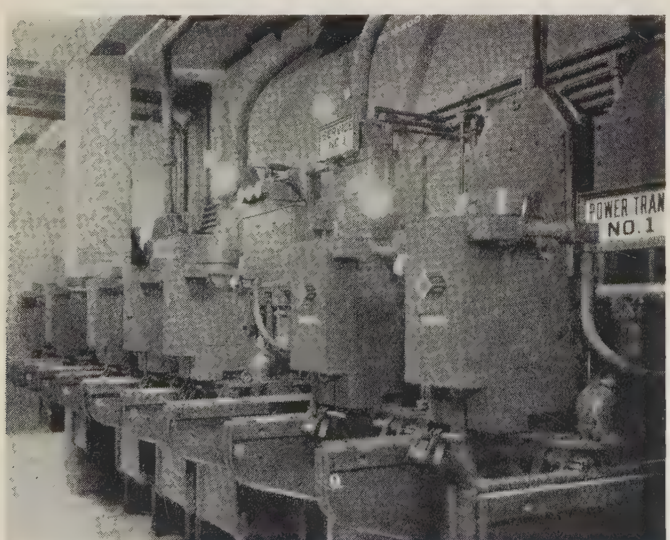

Fig. 2. Seven metalclad oil circuit breakers serve the 13.2-kv bus; 2 for incoming service lines, 2 for power supply, 2 for lighting supply, and one service bus tie

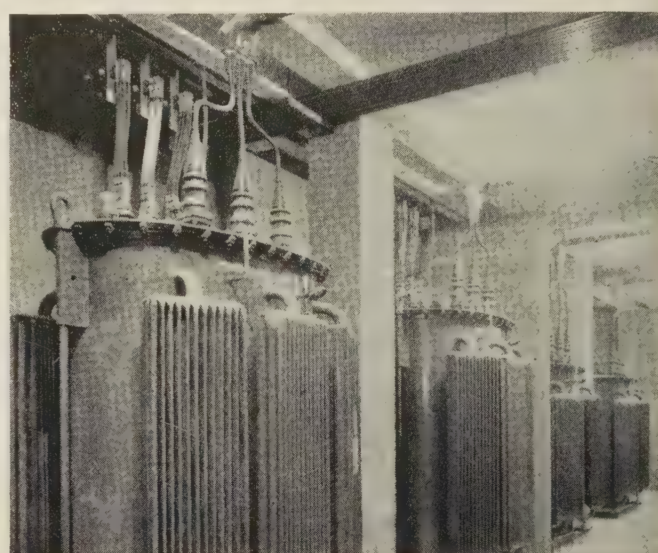

Fig. 3. Oil-insulated self-cooled transformer equipment includes 2 1,200-kva 3-phase units for power supply, 2 750-kva 3-phase units for lighting supply, and one 750-kva 3-phase auto-transformer unit (not shown) for emergency interconnection between the 440-volt power buses and the 115–199-volt 4-wire lighting buses

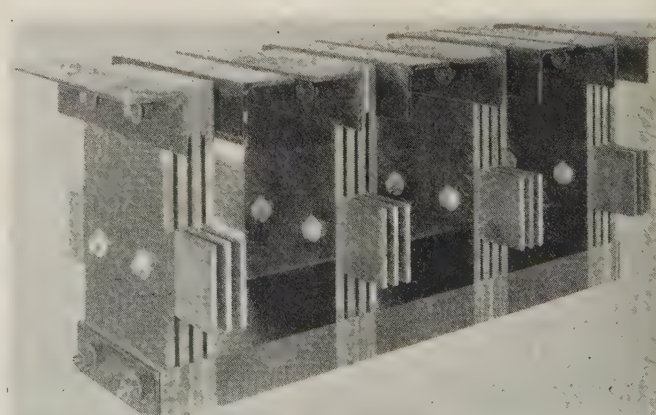

Fig. 4. The use of sheet insulation in the bus assemblies speeded construction, simplified expansion problems, proved no more costly than the more usual types of construction and will expedite inspection and repair

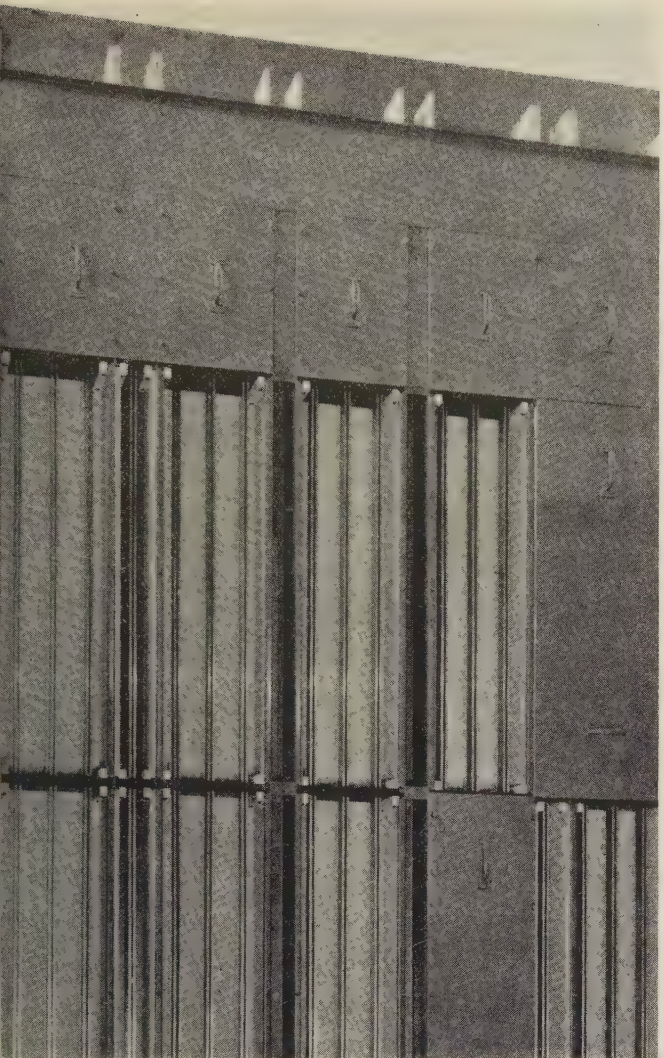

Fig. 5. Steel feeder compartments for the wire shaft which extends the entire height of the building were factory-made in sections for each floor span. Feeder conductors consist of 2 $^1/_4 \times$ 2-in. flat copper strips per phase, designed for a current density of 800 amp per sq in., and supported and spaced by sections of sheet insulation. For tap-offs, special connection boxes fitted with suitable outlets are substituted for the plain covers shown

through the building. In both instances, flat copper strap of convenient proportion was used, spaced, insulated, and supported by flat sheets of composition insulating material. An example of this construction as used in the main low voltage buses may be seen in Fig. 4, where it may be noted also that the supporting sheet insulation is mounted by means of bolts sliding in slotted angle iron pieces which in turn are bolted to the concrete floor slabs. This latter construction is used for long runs and, with flexible cable connections at the ends of the runs, takes care of all temperature expansion and contraction in the bus copper. Electrical and mechanical tests have indicated high factors of safety under both dry and wet conditions.

A related type of construction is used for the main vertical distribution circuits as indicated in Fig. 5. The steel raceways carrying these circuits line the wire shaft on 2 sides from the sub-basement to the 32nd floor. In these steel feeder compartments the flat copper conductors are guided and spaced by sheet insulation spacers located every 4 ft, and the weight is supported by vertical sheets of insulating material. Each phase of busbar feeder is supported at the middle of a 120-ft vertical section by one of these sheet-insulation supports, and the expansion is upward and downward from that fixed point. Woven copper straps, surrounded with composition phase-spacers take care of the expansion between these sections.

Fig. 6. Lighting fixtures are severely simple in contour and finish, and economical in first cost and maintenance. They use 200-watt silvered-bowl processed lamps hung 40 in. below the ceiling on $8^1/_2$ to $9^1/_2$-ft centers

Over the entire length of the wire shaft compartment covers are removable and tap-off feeders are housed in enclosing boxes which fit into the spaces otherwise normally occupied by the compartment covers, thus providing convenient connection at any desired point. Between the adjacent steel feeder compartments there exist, as a "by-product" of the design, wire raceways approximately 3×6 in. in cross-section in which low-capacity rubber-insulated cables and control wiring for various building services are installed. The whole design is safe, fireproof, compact, easily accessible for inspection and repair, economical in first cost, and readily capable of expansion in copper capacity and extra tap-offs without loss of existing materials.

The principal features of illumination in the building, as already mentioned, include relatively high intensity of interior illumination and the neon sign of spectacular proportions on the roof. The exceptionally fine lighting effect with the 19 ft-c of evenly diffused light is secured by the simple unit shown in Fig. 6. To eliminate glare and specular reflection, the light gray walls and white ceilings are painted with a non-gloss finish.

The neon sign on the roof of the building about 500 ft. above the sidewalk is one of the largest in the United States. Each letter is 27 ft high, 9 in. in depth, 15 ft wide, and has a 22-in. stroke. The letters are supported in free space 30 in. in front of a solid metal plate background which spans 120 ft in a horizontal direction. The letters are of simple block

form, painted white and with porcelain enamel face; the background is a deep cobalt-blue. Approximately 1,000 ft of 12-mm 30-ma neon-filled tubes are used to provide illumination at the center of the letter strokes. Visibility and tube light output tests now being conducted may alter somewhat the ultimate tube specifications. It is expected that the sign may be read from a distance of 3½ miles at night and 3 miles in the daytime.

In summarizing some of the outstanding electrical features of this building it is of some interest to note that some 64 per cent of the building motor load is required for the air conditioning and circulating equipment, in addition to the motors installed as spare units. Other pertinent data are given in the following tabulation:

Total connected motor load (exclusive of spare units)		3.620 hp
Elevator load	1,046 hp	
Air-conditioning load	2,310 hp	
Domestic water system	121 hp	
Heating system (for condensate, etc.)	41 hp	
Miscellaneous applications	102 hp	
Total connected motor load (approx.)		3,100 kw
Total connected lighting load		1,676 kw
Grand total connected light and power load		4,776 kw
Total over-all volume of building		7,977,000 cu ft
Total over-all floor space		562,680 sq ft
Space rented by P.S.F.S. (owners)	62,900 sq ft	
Office space, rentable area	328,510 sq ft	
Store space, rentable area	35,140 sq ft	
Non-rentable area	136,130 sq ft	

Researches in Arc Welding

Research of extreme importance in the field of electric welding is reviewed briefly in this progress report. Laboratory tests have demonstrated the impossibility to strike an arc with 120 volts between pure iron electrodes in an atmosphere of pure argon, an observation that may require the modification of basic conceptions of the nature of the electric arc discharge.

By
G. E. DOAN — Lehigh University, Bethlehem, Pa.

J. L. MYER — The Engineering Foundation, New York, N. Y.

IN INDUSTRIAL electric arc welding it is often difficult to say, once good or bad results have been obtained, just why they are good or why bad, and if bad just which of the dozen or more variables in the process was responsible. Obviously many inferior welds are being made in this maze without leading to any definite conclusion. Some of the variables are:

1. Kind of steel welded—that is, the chemical composition, heat treatment, amount of included matter, and surface condition of the parts welded
2. Kind of electrode wire used
3. Preparation of parts prior to welding
4. Kind of welding machine used
5. The human element in the operator's work
6. Subsequent heat treatment of weld
7. A host of others.

It has been proposed that this admittedly complex but industrially important problem be studied by statistical methods in which each variable in every welding operation, together with the degree of success of the operation, be recorded on a series of cards which could then be sorted and the rôle of each variable so evaluated. The other obvious method of attack is the method of abstracting the basic simplified system from the usual complex system; such as using *pure* iron for electrodes and for the parts to be joined, and performing the welding in an inert and therefore non-participating atmosphere. This latter is the method adopted by the present authors and supported by the A.I.E.E. through a grant from Engineering Foundation in 1930, and supported also by Lehigh University.

The successful completion of this project should establish a base line both for the behavior of arcs and for the qualities of welds of pure iron in a non-participating atmosphere. Once the characteristics of an iron arc are known, and once the physical, chemical, mechanical, and metallurgical properties of pure iron welds are established, all more complicated alloys such as commercial steels then could be referred to that base line as a standard, and a judgment could be made of the effects of each alloy element, whether desirable or undesirable. Thus, questions such as: "What should be the phosphorus or sulfur content of steel for welding? Is nitrogen in steel detrimental for welding? What about the best composition for welding wire? What is the action of air on the arc and on the weld metal?" today unanswered, could gradually be answered by reference to the pure iron base line, and the wastefulness and uncertainty of guessing eliminated.

Purity of Materials

Pure iron in the form of wire $^1/_8$ in. in diameter and plates $^1/_8$ in. thick was contributed for these studies. A special method was followed in the preparation of these experimental samples from ferrous chlorid ($FeCl_2$) of reagent grade. This material analyzed as follows:

SO_3	0.0005 per cent
As	0.0000 per cent
Cu	0.0000 per cent
Zn	0.008 per cent

Specially prepared for ELECTRICAL ENGINEERING; includes the essential substance of a progress report presented informally before the welding session of the A.I.E.E. 1932 winter convention, the substance of important discussion arising from that presentation, and the results of subsequent research. *Not published in pamphlet form.*

t then was partially converted to oxid by heating in porcelain dish in an oven. Decomposition was ompleted by adding chemically pure concentrated itric acid (HNO_3) and reheating in an oven. The erric oxid (Fe_2Cl_6) thus produced was reduced in ydrogen in a porcelain tube to give metal powder. After that, the powder was sintered and drawn into a vire, and finally heated in a tungsten grid vacuum urnace.

Argon gas with total impurities amounting to only).0003 (30 parts per million), the purest gas obtainable in quantity, was used for the experiments. The rc chamber, *AC* in Fig. 1, was made of pyrex glass, s also was the auxiliary purification chamber *PC* nd all connections. The auxiliary chamber conained a second arc, supplied by a separate 500-volt ircuit. The arc in this chamber had misch metal reactive metals such as cerium or lanthanum) as one lectrode. With such an electrode, the metal which aporizes from it reacts with any reactive gases in he argon and the compounds so formed deposit on he walls of the chamber. This has been reported pon in some detail by Dr. Saul Dushman in the Franklin Institute *Journal* for June 1931.

Arcs in Argon

In tests made with argon gas as received, in moist ir and in dry air, all metal parts except the iron vires, but including the copper grips *CC* and the glass hambers, were baked out previously in a hydrogen urnace to expel gases. The chambers then were xhausted, filled with argon, again exhausted and illed, and the arc struck between electrodes *EE* by urning the ground glass lug *L*. Runs made without perating the misch metal arc further to purify the rgon gas as purchased, gave a normal arc discharge t *EE* with an impressed potential of 120 volts. The esults so obtained, while valuable, were not espeially noteworthy. The length of the arc was neasured by projection onto a screen; the current nd voltage by Weston standard laboratory meters. The results are shown in the characteristic curves in Figs. 2 and 3. Currents higher than 2.5 amp could ot be used without consumption of the electrode. For comparison with the argon, similar runs were nade in slowly circulating dry air and in circulating noist air. These characteristic curves for dry air nd for moist air arcs of pure iron are included in Figs. 2 and 3.

As Fig. 2 shows, the arcs in air, both dry and moist, equire a substantially higher voltage than the arc in rgon. Also, the arc in air cannot be extended to uch lengths as the arc in argon, which latter goes to) mm without extinction. In most cases the voltage f arcs of a given length in dry air are lower than in noist air, as reported also by Shrum and Wiest at the 931 winter convention of the A.I.E.E. (A.I.E.E. Trans., v. 50, June 1931, p. 650–5). Both 1-amp arcs how irregularly high voltages indicating probably hat the arc was in transition between the first and econd arc stages. Further information concerning his may be found in papers by S. Maisel (*Phys. Zeit.*, . 550, 1904); C. P. Steinmetz (*Trans.* Elec. Cong., t. Louis, v. 2, p. 704, 1904); Cady and Arnold (*Am. Jl. of Science*, v. 24, p. 383, Nov. 1907). At 4 mm the dry air arc curves of Fig. 3 show breaks at all currents. No explanation for this irregularity is offered at present. In other respects the curves in

AC, arcing chamber; C, electrode holders of copper with cooling fins; CL, current leads; E, pure iron electrodes; L, lug ground into stopcock with device for moving upper electrode; PC, purification chamber; M, misch-metal purification arc; VL, voltmeter leads

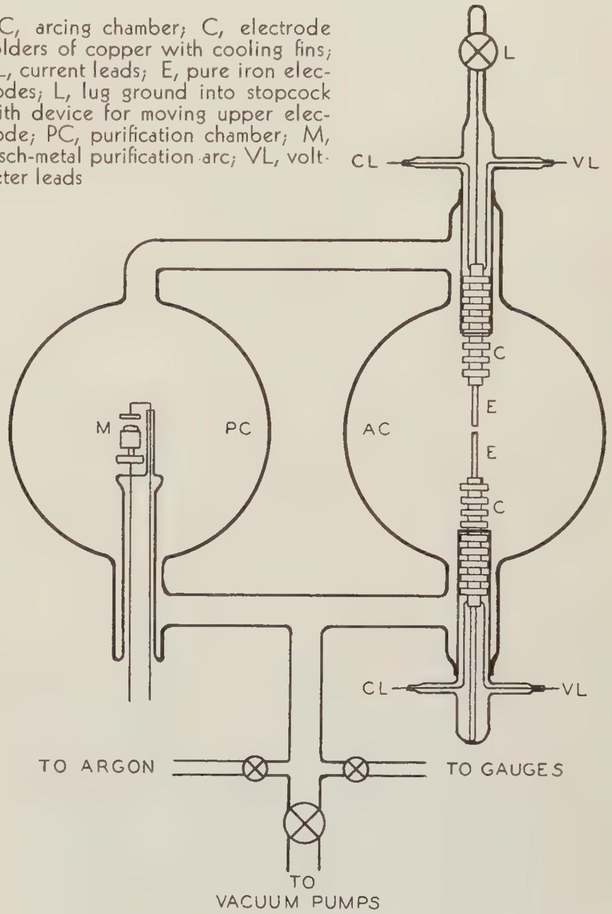

Fig. 1. (Above) Apparatus used for the determination of the characteristics of arcs drawn between pure iron electrodes in an atmosphere of argon gas

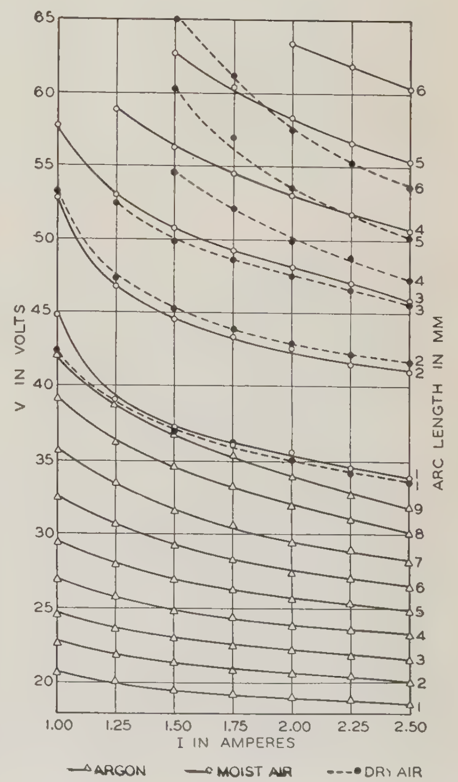

Fig. 2. (Right) Comparison of the voltampere characteristics of the iron arc in argon gas, moist air, and dry air

air and those in argon are quite regular. The 1-mm curve in argon is approaching rapidly the condition of constant minimum voltage, independent of arc current.

The arc in argon deposited a black coating on the chamber, probably condensed iron vapor; in air the deposit was of a brownish red color like iron oxid. The arc was difficult to strike at first when new electrodes were used in dry air, but not so in moist air.

Both the arc in argon and in moist air satisfy W. B. Nottingham's equation

$$V = A + \frac{B}{I^n} \text{ with } n = 2.62 \times 10^{-4}T$$

(where T is the boiling point of the anode) as given in the A.I.E.E. JOURNAL for Feb. 1923, p. 302.

Arc in Drastically Purified Argon

The most astonishing results came when a final drastic purification of the argon as purchased was carried out by circulating it through the misch-metal-arc purification chamber for several hours before the iron electrodes *EE* were touched. In these runs the greatest care was exercised to obtain absolute cleanliness. An entirely new glass system and new iron electrodes were used each time. All parts (except the iron) were thoroughly baked out in the furnace prior to use. After circulating the argon for several hours (by convection) between the purification chamber and the arc chamber proper, the electrodes *EE* with a potential of 120 volts across them were touched and slowly separated. In all cases, however slow and cautious the separation, no arc could be struck. It was simply *impossible* to strike an arc between the pure iron electrodes with 120 volts in an atmosphere of *pure* argon.

The implications of this result are far reaching. It has never been supposed previously that an arc required for its establishment a complex atmosphere, or one containing chemically active gases such as the nitrogen and water vapor which constituted most of the 30 parts of impurity in 1,000,000 parts of "impure" argon as received. The low voltage electrical discharge through gas or vapor (i. e., the arc discharge) has been explained by Dr. K. T. Compton (*Phys. Rev.*, v. 21, p. 266, 1923) on the basis of thermionic emission from a hot cathode, and by Dr. Irving Langmuir (*G. E. Rev.*, v. 26, p. 735, 1923; *Science*, v. 58, p. 290, 1923) from the accumulation opposite the cathode of a positive space charge which pulls electrons out of the cathode, whether hot or cold. Most arcs can be accounted for successfully by one or the other theory. Neither theory postulates the necessity for the presence of chemically active atoms or molecules in the arc environment, and yet the refusal of the arc to form in the pure gas used in the experiments here reported indicates this new view. Arcs in argon have been reported frequently in the past, but never in a gas so highly purified as in the present studies. It is possible that our most basic conceptions of the nature of the arc discharge may require modification to conform to these observations of the iron arc in argon.

If the rigorousness of the purification were relaxed in the slightest degree—if, for example, the surfaces of the iron electrodes were not scrupulously cleaned immediately before insertion into the chamber—the normal arc would strike without difficulty; or if the copper grips *CC* were not baked thoroughly, a discharge between the lower grip (copper) and the upper electrode (iron) about $1^1/_2$ in. long would set in, and after a minute or so return to the electrode tips as a normal iron arc. In the tests which revealed this possible condition apparently enough gas had been liberated from the impure copper grip to support the arc in the then contaminated argon gas. However, when purification was carefully prosecuted and complete it was impossible to strike an arc in any one of the 4 glass systems built.

Hypotheses to Explain Non-Arcing

Hypotheses to explain this new characteristic of the arc, at least for the iron arc in argon, were offered following presentation of these results at the 1932 A.I.E.E. winter convention by Dr. K. T. Compton, Dr. Saul Dushman, and Dr. Joseph Slepian. Because of their considerable theoretical interest, these hypotheses are stated in the following paragraphs.

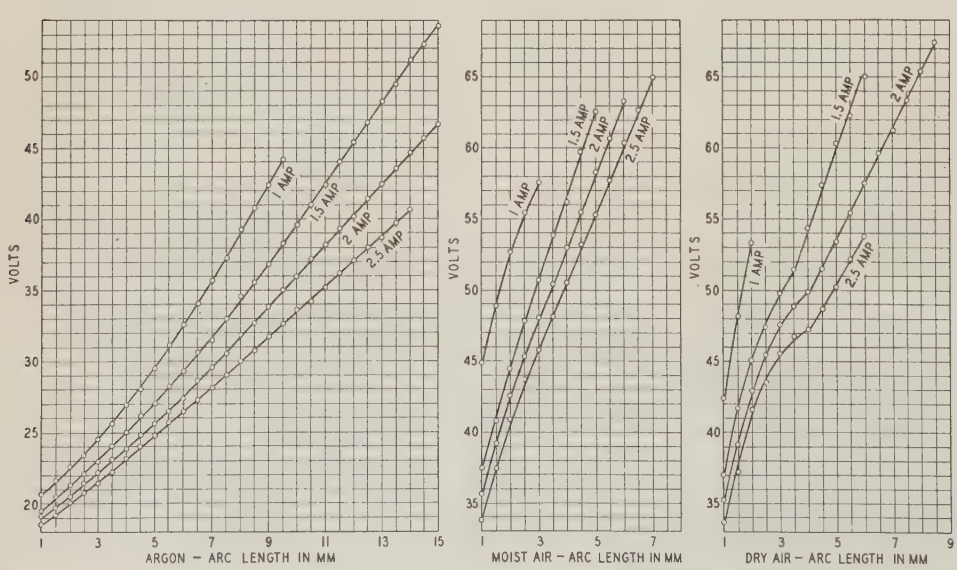

Fig. 3. Comparison of the voltage-length characteristics of arcs drawn between pure iron electrodes in an atmosphere of argon gas with impurities present (left); in moist air (center); and in dry air (right)

In commenting on the inability to obtain the normal arc under these "drastically purified" conditions, Dr. Compton in a private communication suggests that possibly an oxid layer on the cathode is a prerequisite in maintaining the proper cathode temperature (in accordance with the thermionic emission theory of the arc). Such an oxid layer might raise the cathode temperature by virtue of its electrical resistance or its thermal insulating properties. Compton further suggests that the elastic electron impacts with argon molecules might so scatter the current over the cathode as to make impossible the establishment of a cathode spot.

Dr. Dushman in a private communication, also considering the arc in terms of thermionic emission, remarks that a thin film of iron on an oxid surface of the metal has a far greater thermionic emission than has the uncontaminated metal surface itself. He is undertaking new experiments in a study of such effects.

Dr. Slepian discussed the subject before the convention in the light of Langmuir's space charge theory. For low current arcs, such as used in the present experiments, the positive space charge just outside the cathode is very small. Consequently, the lines of force of such a charge are spread out so widely that the electric field between the space charge and the cathode is weakened materially. If the field strength drops below a certain value, it is impossible for electrons to be "pulled out" of the cathode, and hence the discharge cannot be supported.

Because of the indicated basic nature of the discovery, these experiments are being continued as part of a comprehensive program, both in America at Lehigh University and abroad in Berlin whence the junior author of this report has gone to continue certain phases of the work. It is contemplated that a complete, detailed report on the studies of the pure iron arc in argon may be published soon by the American Welding Society. Concurrently, the efforts to determine the properties of pure iron welds are being continued; welds of pure iron and also welds of commercial steel have been prepared in "impure" argon and in air. The chemical, physical, mechanical, and metallurgical properties of these welds now are being ascertained.

Electrical Operation on the Great Northern

To eliminate a circuitous mountain crossing which had become the "bottle neck" of the line, the Great Northern Railway built a tunnel almost 8 miles long, relocated 17 miles of track, and electrified 73 miles of line. Some of the operating experiences and savings effected in the 3 years since electrical operation was begun are outlined in this article.

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ELECTRIFICATION of the Cascade Division of the Great Northern Railway main line between Skykomish and Wenatchee, Wash., has doubled the capacity of that portion of the line and has resulted in many operating advantages. The electrification, which embraces a total of 73 route miles, was carried out in conjunction with the building of a new tunnel 7.79 miles long, and the relocation of approximately 17 route miles of troublesome track and other minor improvements, aggregating the total expenditure of approximately $25,500,000. All of these improvements were placed in operation at about the same time so that there has been no opportunity to make a direct and segregated comparison of operating expenses that would indicate definitely the advantages of each improvement separately. The new tunnel represented the second undertaking of that nature in the history of the Great Northern Railway's route across the precipitous Cascade range.

Fig. 1. Locomotive and train leaving western end of new Cascade tunnel

The original route, which was placed in operation in 1893, went over the range through Stevens Pass at an elevation of 4,059 ft. It was possible to keep the maximum grade at 2.2 per cent up to 3,382 ft on the

Essentially full text of a paper "Electrical Operation on the Cascade Division of the Great Northern Railway" (No. 32-110) presented at the A.I.E.E. Pacific Coast convention, August 30–September 2, 1932.

eastern slope, and to el 3,126 ft on the western slope. These points were approximately 2.7 miles apart by direct line through the mountain or 4.5 miles over the pass. A tunnel between these points was considered at the time, but it would have cost more and taken much longer to tunnel than to build the road through the pass, two very important items in those days; consequently the line was built through the pass. This was done by increasing the ruling grade to 4 per cent and resorting to an 8-point switchback, involving approximately 12 miles of track. As had been foreseen, this switchback became the proverbial "bottle neck" of the line and with the natural increase of traffic, its capacity soon was reached. This was particularly so during the winter months when there was apt to be an aggregate fall of from 50 to 100 ft of snow at a rate as high as 8 to 10 in. per hr at times.

To overcome these difficulties and to improve the service, the construction of a 2.63-mile tunnel was begun in 1897. This tunnel which was placed in operation in 1900 ran in a straight line at a constant grade of 1.695 per cent eastbound, cut out the entire switchback, and eliminated 2,332 degrees of curvature and all grades in excess of 2.2 per cent. This improvement shortened the route approximately 9 miles which reduced the running time of all trains about 2 hr with a corresponding decrease in operating expenses.

First Tunnel Electrified in 1909

With a further increase in traffic the ventilation of this tunnel became so unsatisfactory with the operation of coal burning steam locomotives that the tunnel and tracks at each end were electrified. The

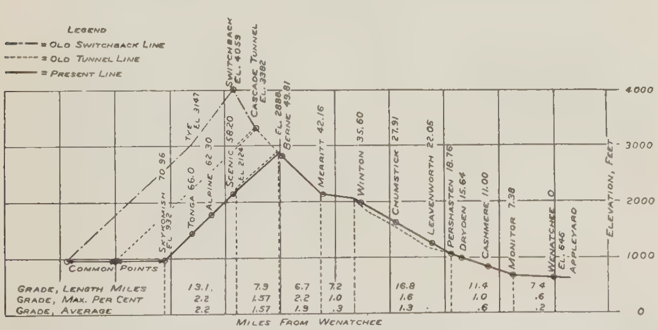

Fig. 2. Condensed profile of the old and new routes over the Cascade range

Table I—Comparison Between Old and New Lines

	Old Line	New Line	Advantages of New Line
Length in miles	17.67	9.99	7.68
Maximum curve, deg	10.00	6.00	
Total curvature, deg	2,128	187	1,941
Maximum grade, %	2.2	2.2	
Tunnel grade, %	1.695	1.565	
Summit elevation, ft	3,382	2,881	501
Total rise westward, ft	546	45	501
Total fall westward, ft	1,325	824	501
Total length of snow shed, miles	6.04		6.04
Total length bridges, miles	0.23	0.04	0.19
Total length tunnels, miles	3.66	7.79	

3-phase system was selected for this installation largely because of its ready adaptation to regenerative braking. It was the first and only application of this system in America, as well as the first regenerative braking on a steam railroad. (See "The Electric System of the Great Northern Railway at Cascade Tunnel," C. T. Hutchinson, A.I.E.E. Trans., v. 38, 1909, p. 1281.)

Electrical operation of this tunnel was begun in July 1909. The 3-phase equipment satisfactorily met the original requirements and was continued in service until March 1927 when it was replaced by the present single-phase system. The only notable modification of the 3-phase equipment was the installation of the necessary wiring and switches for a concatenated connection of the traction motors to provide a running speed of $7^1/_2$ mph in addition to the speed of 15 mph originally selected. This was done in the latter part of 1923 when the division point of the road was removed from Leavenworth to Wenatchee (Appleyard) which increased the length of the freight run from 109.3 miles to approximately 132 miles.

At the beginning of electrical operation, the freight trains did not exceed 1,600 tons trailing so that 3 of the 115-ton electric units were used to take this train with the road steam locomotives through the tunnel at one trip. With a gradual increase in train weights it had been found necessary to cut the heavier trains and take them through in 2 trips on account of the limited capacity of the Tumwater power plant; this caused a delay of about an hour. By using the half-speed connection it was possible to use 4 electric units per train and to haul up to 2,200 tons trailing plus the steam road locomotives through the tunnel at a single trip without exceeding the capacity of the power plant.

Electrification Extended

This lessening of the total number of trips per day left the electric locomotive crews and the power plant idle a greater portion of the time. Consequently consideration soon was given to the extension of the electrification from the west portal of the tunnel to Skykomish, a distance of approximately 21 miles, so that the electric units might be used to replace the steam locomotives used in the helper service on the 2.2 per cent grade up the west slope. A study of this plan indicated that, if adopted, quite a saving in operating expenses should result in addition to some saving in time. There would be practically no increase for electrical operating cost as the extended service would increase only the load factor without adding greatly to the crew hours paid for, and the necessity for the stop at the west portal of the tunnel would be avoided.

In the consideration of this extension it was realized that a new tunnel undoubtedly would be constructed within a few years, involving a new route which would result in the abandonment of at least 9 miles of this proposed extension as well as the old tunnel electrification. It was necessary therefore that the expenditure for the extension be kept at a minimum and that any additional electric locomo-

ives required be capable of use on any desired change f route.

The 3-phase locomotives then in use in the tunnel vith their constant speed characteristics and with nly 2 operating speeds were not best suited to meet perating conditions on the extension. This fact, ogether with the complications in the contact system wing to the necessity for the 2 overhead wires, made t unlikely that this system would be chosen if the lectrification were extended beyond the mountain ection. After careful consideration the single-phase notor-generator type of locomotive was chosen as eing best suited to meet all of the existing condiions. This locomotive embodies a combination of he most desirable features of both single-phase and l-c locomotives. The speed can be varied to any legree necessary to conform to either the train weight r available power, or both; this type of locomotive hus is well adapted to operation as a helper to a team locomotive. For the extension planned, one louble-unit class 1 – D – 1 + 1 – D – 1 motorenerator locomotive originally was ordered.

Generators at the power house were of liberal lesign, having sufficient excess capacity over the vater-wheels to permit their operation single-phase. Available capacity at the power house was approxinately 4,000 kw.

NEW TUNNEL AND FURTHER ELECTRIFICATION

A few months after the equipment for this extenion had been ordered and before electrification had een completed, a decision was reached to construct a ew tunnel 7.79 miles in length. The new route vould leave the main line at Scenic on the west slope nd join it again at Berne on the east slope, thus subtituting 9.99 miles of new route for 17.67 miles of the ld route with advantages as indicated in Table I.

The new line would remain below the elevation of eaviest snowfall and would traverse a route less ubject to drifts and slides than was the old route. Also a relocation of the line between Winton and Peshastin had been surveyed which would (1) avoid ome troublesome line in the Tumwater Canyon; 2) reduce the maximum grade from 2.2 per cent to .6 per cent, the maximum curve from 10° to 3°, and he total curvature 1,286°; and (3) shorten the line bout $1^1/_4$ miles.

With these revisions of line in view and with a urther definite decision to electrify the entire line etween Skykomish and Wenatchee and to leave off he steam locomotives between these points, the haracter of the service was so changed as to make it lesirable to consider some revision in the additional notive power required. Between Merritt and Wenatchee over the new route, a distance of 42 miles, the ine would permit speeds of 50 mph safely, whereas he line between Skykomish and Cascade Tunnel did ot permit speeds in excess of 30 to 35 mph; the new ocomotives (class 1 – D – 1 + 1 – D – 1) had een designed accordingly with a maximum safe peed of 40 mph. With only 73 route miles electriied requiring so few locomotives, it was desirable to ave all locomotives interchangeable between pasenger and freight service and that any locomotive be

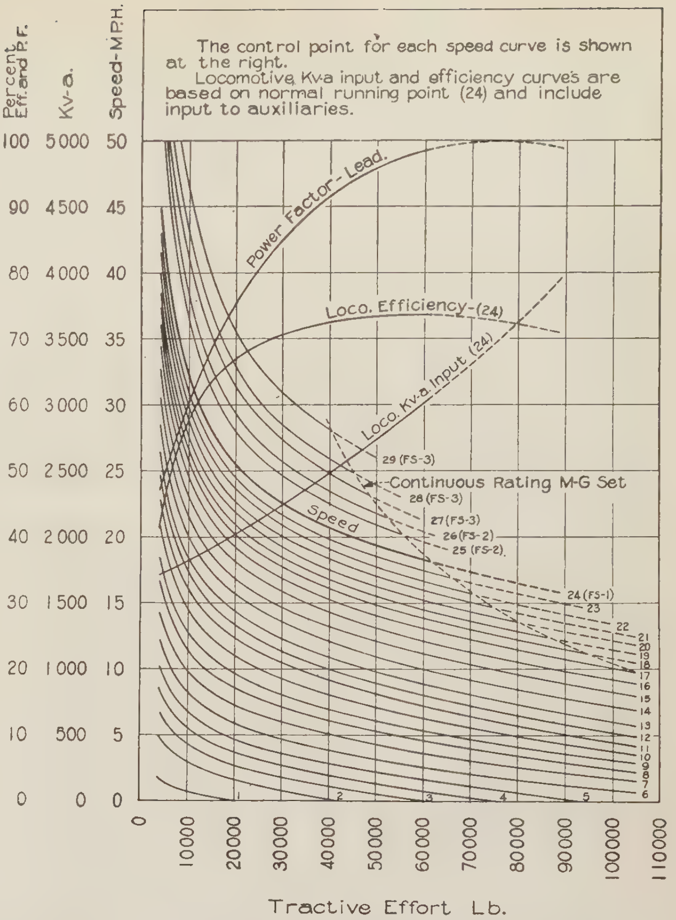

Fig. 3. Characteristic motoring curves of the 1 – C + C – 1 10,500-volt 25-cycle locomotive

operatable in the same train with any other locomotive. Regular passenger trains operated over the line varied from 8 to 12 cars, aggregating from 700 to 1,000 trailing tons; freight trains ordinarily would range between 2,500 and 4,000 tons trailing. Grades range from 0.2 to 2.2 per cent, the average up grade for the line being approximately 1.29 per cent (see Fig. 2).

NEW LOCOMOTIVES DESIGNED

To meet these new conditions, a new locomotive known as class 1 – C + C – 1 was proposed, pertinent data for which are given in Table II in comparison with the double unit locomotive (class 1 – D – 1 + 1 – D – 1) for the extension from Cascade Tunnel to Skykomish.

Class 1 – C + C – 1 locomotives, designed particularly for mixed service over the new line, will handle a 1,000-ton trailing train at 18.5 mph on the 2.2 per cent grade and up to about 45 mph on the 0.2 per cent, averaging over the entire up grade portion about 28.6 mph, the average output of the motors being approximately 2,100 kw and the rated load factor, 84 per cent. On the down grades the speed is limited to a maximum of 50 mph. Regenerative features of the locomotive provide satisfactory control of the speed on the varying down grades to meet any conditions imposed by curvature, track conditions, or schedule requirements. Figs. 3

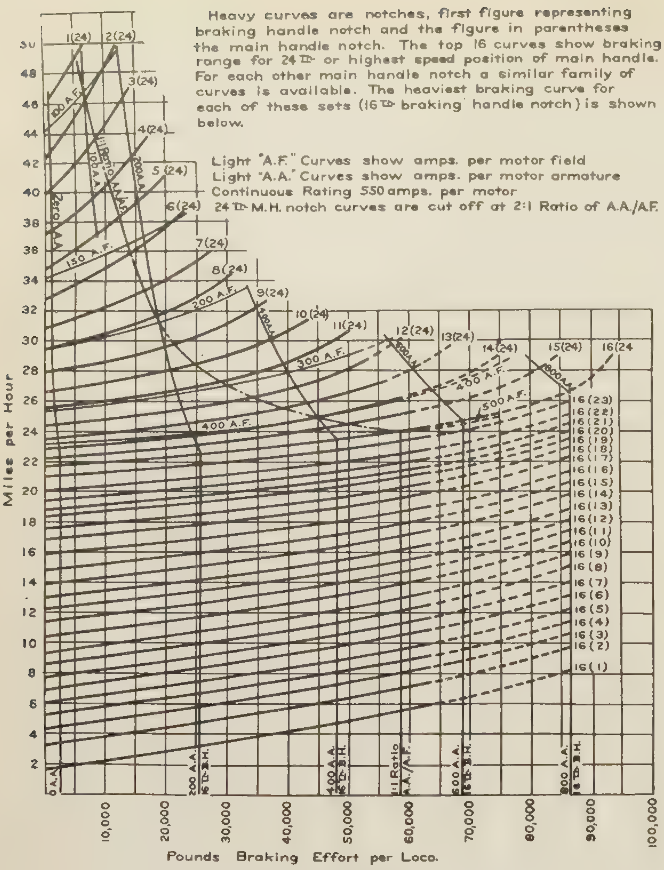

Fig. 4. Characteristic braking curves of the 1 − C + C − 1 10,500-volt 25-cycle locomotive

and 4 give, respectively, the motoring and braking characteristics of this locomotive.

Of the 1 − D + D − 1 locomotives 2 were placed in the Skykomish-Cascade tunnel service in March 1927, 2 in the fall of 1928, and 1 early in 1929. The 5 locomotives of this class thus have been in service for the equivalent of about 23 locomotive years. Two of the 1 − C + C − 1 locomotives were placed in the Skykomish-Cascade tunnel service in September 1927, 2 others a year later and 4 were ordered in October 1929, 9 months after the complete electrification had been placed in operation. These locomotives now have been in service about 2 years so that the 8 units of this class have been in service the equivalent of 25 locomotive years.

Of this grand total of 48 locomotive years, approximately 9 years were in the service between Skykomish and Cascade Tunnel as originally planned. This service consisted of helping the regular steam locomotive up the 2.2 per cent grade to the entrance of the tunnel, through which the grade was reduced to 1.695 per cent, making it possible to shut off the steam while in the tunnel.

During 1927–1928, freight trains, ranging from 2,500 to 3,500 tons trailing, were brought to Skykomish by 2 steam locomotives. There, the rear steam locomotive was dropped off and replaced by 2 electric locomotives, one ahead of the steam road engine and one in the rear of the train. In the beginning, the rear locomotive was put at the extreme ends of the trains, but later it was found to be safer to place the rear unit about half to two-thirds back in the length of the train to prevent possible buckling of the train at some weak spot. These heavy freight trains were taken from Skykomish to Cascade tunnel, 25 miles, in $1^3/_4$ hours whereas with steam operation from 4 to 5 hours usually were required. On passenger trains, one electric locomotive was placed ahead of the steam locomotive to help propel the train, in accordance with requirements, to the entrance of the tunnel through which the electric locomotive hauled the train and engine unaided. This operation was begun in March 1927 and continued until the opening of the new tunnel January 12, 1929.

Wenatchee being a division point, all engines and crews of both passenger and freight trains are changed on arrival there. On arrival of all trains at Skykomish from the west, the engine crews shift from the steam locomotives to the electric and continue the trip to Wenatchee; all westbound engine crews similarly transfer from the electric to the steam locomotives and continue to Seattle.

Early Operating Troubles in New Tunnel

The first 10 days of electrical operation over the new route through the new tunnel was without serious incident. On 2 occasions before the opening of the tunnel, there had been instances of arcing to ground from terminals of current transformers while locomotives were standing inside the new tunnel near the east portal. However, no serious damage resulted.

On one occasion in the old tunnel a transformer had been lost and an arcover at current transformer terminals on 2 locomotives had occurred in zero weather during the first winter after electrical operation began there. A frequency changer set used in connection with the work on the new tunnel had burned out and other disturbances on the line had occurred on the same day, so it was thought these troubles were due to surges. Additional insulation was installed on the terminals and transformers where the trouble seemed to have originated and no further trouble occurred. Therefore when arcovers began to occur in the new tunnel, steps were taken immediately to have 3 surge recorders placed on the trolley circuit, one at each end of the tunnel and one midway between. A fourth recorder was placed on a locomotive running over the entire line. These had just been installed when sub-zero weather arrived and more serious troubles began.

Within less than a week 4 locomotive transformers burned out and several arcovers occurred from terminals of current transformers to ground. In every instance, these troubles occurred on a locomotive attached to a freight train westbound through the tunnel. No trouble was experienced on locomotives hauling passenger trains nor on locomotives eastbound hauling freight trains. The loss of 4 out of a total of 14 main transformers within a week was alarming and even seriously threatened the possibility of continuing to handle all of the traffic over the line electrically.

The surge recorders were left on the circuit from 3 to 4 weeks, during which time there were arcovers and burnouts of transformers. A careful examina-

on of all the records, however, failed to indicate that iere had been any surges registered higher than oout 2 times normal voltage. This being well ithin the limits ordinarily expected from necessary witching operations, surges were eliminated from esponsibility for the trouble.

roubles Due to Condensation

When the temperature outside the tunnel was elow freezing, some signs of condensation had been oted on the outside of the locomotive cab and on the iside near the air intakes. This condensation inreased as the temperature outside approached zero. he east end of the new tunnel is at about 634 ft reater elevation than the west end and this, together ith the piston action of the moving trains, afforded atisfactory ventilation ordinarily, but it was found hat the temperature of the air in the tunnel near the iddle varied only between 50 and 65 deg F irrespecive of the outside temperature (see Fig. 5). Since he draft was toward the east portal, the rise in temerature entering the tunnel from that end was much iore rapid than from the west end. To add to the ifficulties, the outside temperature on the east side f the mountain usually was lower than on the west ide.

A locomotive starting from Wenatchee with normal entilation, when the outside temperature was below ero, would show little rise in temperature by the time had reached the east portal of the tunnel so that nmediately after entering the tunnel and encounterig the much warmer air, frost began to collect on the utside of the cab and truck; within 2 or 3 minutes, he locomotive was coated thickly with frost crystals, he accumulation of which continued until the locoiotive began to warm up when this frost would beome liquid and begin to drop off. The same action ook place inside the locomotive but to a lesser extent.

At times, when the moisture precipitation was reatest, corona was observed on the 11-kv circuit, articularly at taped joints and terminals. It was o doubt the corona at the surface of the heavily aped terminals connecting the current transformers n the 11-kv circuit to the primary of the locomotive ransformer that caused the arcovers to ground at his point.

The moisture condition was aggravated by the arge volume of air drawn into the locomotive by the lowers for cooling the electrical equipment. The utside temperature east of the tunnel varies from round 100 deg F in summer to 15 deg below zero uring winter, making it necessary to supply as iuch as 40,000 cu ft of air per minute during the ottest weather.

Experiences with other locomotives requiring much ess ventilating air had indicated conclusively that uring rain or snow storms dangerous quantities of ioisture would be carried inside the locomotives by his large volume of air. To protect the electrical quipment from this danger the louvers for the – C – C – 1 locomotives had been provided at he factory with adjustable shutters by means of vhich the openings for air intake could be varied om fully open to fully closed. In order to insure proper ventilation of the apparatus when the louvers were closed, dampers were placed in the outlets for the air from the apparatus to direct the air back into the locomotive for recirculation through the apparatus, thus replacing the moisture-bearing air from the outside.

Trouble Cured by Closing Ventilating Louvers

While it had not been foreseen that there would be so great a variation between the temperature outside and inside the tunnel as to cause serious trouble, these provisions for closing the louvers and recirculating the inside air were readily applicable to overcoming this unexpected danger. By closing the louvers and adjusting the dampers at the beginning of a trip the air inside the locomotive was raised easily to a temperature so nearly approaching that of the air inside the tunnel as to prevent any harmful precipitation of moisture. When weather conditions are such as to require the closing of the louvers the temperature outside is never at a maximum so that recirculation of the inside air does not cause excessive heating of the apparatus.

Since operation with closed louvers was begun, the electric locomotives have operated through 3 winters without any trouble from condensation. Moreover, this trouble from condensation is the only serious difficulty that has been experienced in the operation of the electrified line.

Cost Data and Comparisons

Motor-generator locomotives are well adapted to service where the freight trains may vary from 2,500

Table II—Comparison Between the 2 Types of Motor-Generator Locomotives in Use

Classification	1–C + C–1	1–D–1+1–D–1
Total weight, lb	539,000	715,400
Weight on drivers, lb	426,200	550,000
No. of driving axles	6	8
Weight per driving axle, lb	71,030	68,750
Weight on guiding axles, lb	112,800	165,400
Weight per guiding axle, lb	56,400	41,350
Length over couplers	73 ft. 9 in.	94 ft. 4 in.
Total wheel base	58 ft. 8 in.	78 ft. 11 in.
Rigid wheel base	15 ft. 4 in.	16 ft. 9 in.
Height, pantograph down	15 ft. 3 in.	15 ft. 10 in.
No. traction motors	6	8
Tractive effort continuous rating, lb	60,500	88,500
Tractive effort 30% adhesion, lb	127,860	165,000
Speed at continuous rating, mph	18.6	15.5
Maximum safe speed, mph	50	40
No. ordered	8	5
Transformer, secondary volts	2,300	1,100

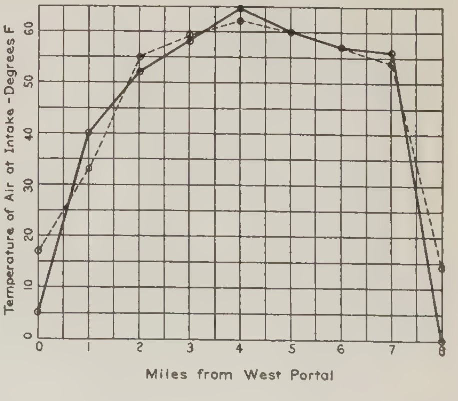

Fig. 5. Curves showing typical temperature variation in the new Cascade tunnel during near-zero weather

to 5,000 tons trailing and where it is desirable to limit the maximum power demand to the most economical point. However, the first cost of this locomotive and its weight per horsepower is apt to be greater and its over-all efficiency somewhat less than of other types. The maintenance cost of these locomotives during the 3 years 1928–30 has been 28.66 cents per locomotive mile, or 13.65 cents per 100 tons on drivers. A comparison of these costs with those of 3 other electrified roads using locomotives in similar service with regenerative braking on heavy grades is as follows:

	Locomotive Miles	Per Locomotive Mile	Per 100 Tons on Drivers
Chicago, Milwaukee, St. P. & P.	7,939,539	14.20c	6.92c
Norfolk & Western	1,520,608	46.82	17.60
Virginian	1,562,574	48.49	12.26
Great Northern	937,492	28.66	13.65

A direct comparison of operating expenses between steam and electric operation is impossible for the reason that the route now being operated electrically never has been operated by steam. Furthermore, the shortening of the route and the reduction of elevation by the new tunnel have had important parts in reducing the operating expenses.

However, early in 1920, a study of the old line was made with a view to electrification. In this study operating data and costs were carefully prepared covering 12 months ending September 30, 1919 for steam operation between Skykomish and Wenatchee through the old tunnel. These data are still available for comparison with corresponding costs covering the year, 1929, with electrical operation over the new line. Table III shows a comparison of those items of operating expense vitally affected by electrical operation for the 2 years mentioned.

The total cost of the improvements involved in building the new line and the electrification was, in round numbers, $25,500,000 made up as follows:

7.79 miles tunnel complete	$14,000,000
17.0 miles new track	5,000,000
73 miles electrification	6,500,000

Segregated costs of the electrification were approximately as shown in Table IV.

In reviewing the study made in 1920 relative to the electrification of the old line for comparison with the present electrification, it was interesting to find an estimate of the cost of the proposed electrification of 80 miles of line between Leavenworth and Gold Bar through the old tunnel and which would require the same electrical equipment as the present electrification. The estimated cost of the complete electrification at that time was $6,463,750, or $80,800 per route mile; of this amount, $3,250,000 or 50.28 per cent, was for electric locomotives. Savings from electrical operation estimated for items affected were $639,703.

While a large portion of the savings shown in Table III favorable to electrical operation is due to the new tunnel, this improvement would not have been practical without electrical operation. The decision to build the tunnel was reached only after a careful report had been prepared which indicated that interest on the capital charge would be covered easily by the saving in like charges for new snow shed construction and in maintenance charges for these sheds in the future, thus putting the investment for the new tunnel on a self-supporting basis.

Saving in operating expense shown in Table III is equal to 12.63 per cent on the gross cost of the electrification which, together with the shortened time and other improvements in the service, makes the electrification a favorable investment with a normal volume of traffic. The electrical equipment is easily capable of handling an increase of 50 per cent in the freight traffic and with such an increase, the saving in operating expenses would be in about the same pro-

Table III—Comparison of Steam and Electric Operating Costs

	Steam	Electric	Difference Amount	Difference % of Steam
Route miles	80	73	7	8.8
Locomotive miles	767,151	406,910	360,241	47.0
1,000 ton miles	485,000	408,108	76,892	15.8
Train miles	607,000	292,930	314,070	51.7
Costs—				
Enginemen	$ 276,597	$ 80,049	$196,548	71.0
Trainmen	175,819	77,413	98,406	56.0
Fuel or power	659,850	269,298	390,552	59.2
Locomotive repairs	243,114	109,085	134,029	55.1
Enginehouse	67,260	22,885	44,375	66.0
Lubricants	3,325	5,525	+2,200	66.2
Supplies	3,414	1,643	1,771	51.9
Water	1,308		1,308	100.0
Substations	5,543	5,995	+452	8.2
Distribution	3,411	41,917	+38,506	1128.9
Total	$1,439,641	$613,810	$825,831	57.3
Avg. cost per 1,000 ton miles	2.968	1.504	1.464	49.3
Avg. cost per train mile	2.372	2.095	0.277	11.7
Avg. tons per train, freight	1,882	3,021	1,139	60.5
Avg. tons per train, passenger	494	568	74	15.0
Avg. road time, freight	13.4	5.5	7.9	59.0
Avg. road time, passenger	4.1	2.8	1.3	31.7
Avg. mph, freight	6.0	12.9	6.9	115.0
Avg. mph, passenger	19.4	25.5	6.1	31.4

Proportioned Between Freight and Passenger Service

	Steam Freight	Steam Passenger	Electric Freight	Electric Passenger
Locomotive miles	466,428	300,723	199,806	207,104
Train miles	207,286	399,720	98,478	194,452
1,000 ton miles	390,000	95,000	297,550	110,558
Total cost, items affected	$1,067,641	$372,000	$391,810	$222,000

Table IV—Itemized Cost of the Skykomish-Wenatchee Electrification*

	Amount	Per Route Mile	Per Cent of Total: Less Locomotives	Per Cent of Total: With Locomotives
Substations, etc	$1,062,611	$14,556	33.63	16.21
Transmission system	531,967	7,287	16.70	8.12
Power distribution	368,040	5,042	11.56	5.62
Poles and fixtures	567,265	7,771	17.81	8.66
Telephone and telegraph changes	157,440	2,157	4.94	2.40
Signals and interlocks	155,970	2,136	4.90	2.38
Shops, machinery, tools	138,357	1,895	4.34	2.11
Engineering	203,512	2,788	6.39	3.10
Total less locomotives	$3,185,162	$43,632	100.00	48.60
Locomotives	$3,368,338	$46,141		51.40
Total	$6,553,500	$89,773		100.00

* $174,604 credit deducted for 14 miles of electrified line abandoned. Route miles 73; track miles 91.

ortion, making the return on the gross investment r electrification approximately 18 per cent.

Capacity of this portion of the line which, with a ongestion of traffic, undoubtedly would become the ottle neck of the system with steam operation has een increased 100 per cent as is indicated by the ecords. These records show that whereas with eam operation in 1920, 3 steam locomotives averaged approximately 6 hours to take a 2,250-ton train the 24.3 miles from Skykomish to the old summit, in 1929 2 electric locomotives averaged about $1^1/_2$ hours to take a 5,000-ton train the 21.2 miles from Skykomish to the new summit. In ton miles per train hour, this is 70,666 for the electric as against 9,112 for steam, a ratio of 7.7 to 1 in favor of electrical operation.

Distribution System Lightning Protection;

Interconnection of Primary Arrester Ground and Secondary Neutral

Although distribution transformers have high impulse strength compared to their normal voltage ratings, they still flash over and fail in service even when protected by arresters. Interconnecting the ground lead of the primary arrester with the transformer secondary neutral limits the voltage across the transformer insulation to that permitted by the arrester alone, and introduces no additional hazard on the low voltage circuit where secondary neutral ground resistances are low. This is the first group of articles dealing with the subject of protecting distribution systems from lightning; articles dealing with other phases of the problem will appear subsequently in ELECTRICAL ENGINEERING.

LIGHTNING SURGES in ordinary rban distribution circuits manifest themselves in a anner somewhat different from that of those ccurring on high voltage transmission lines. In the istribution circuit the arrester spacing usually is uch that the distance traveled by the voltage wave ill be short, the crest voltage appearing on the line ill be limited, and the surge will manifest itself as urrent through one or more arresters. The current ave, both as regards magnitude and shape, is etermined largely by the lightning stroke and but ttle by the characteristics of the distribution cir-uits. On rural lines the exposure between arresters much greater, so that in addition to surges originat-ng near the arrester there are surges arriving over a ngth of line. Crest voltages of these surges are mited by the line insulation.

Experience has shown that although failures of distribution transformers and the blowing of fuses during lightning storms are reduced greatly by the application of lightning arresters, the record of protection is not so good as the strength of the transformer and performance data of the arrester would indicate it should be. In general, the ratio between the strength of the transformer insulation and the voltage allowed by the arrester is not far from 4 to 1. With such a large margin, failures of transformers or fuse blowing due to lightning should be practically eliminated except in the case of a direct stroke at the transformer location, a relatively infrequent source of trouble.

Protection now commonly employed for distribution transformers provides for phase and neutral arresters on the primary side of the transformer. With few exceptions these arresters are connected to a common ground lead which in turn is connected to a driven ground rod at the base of the pole. This arrangement is based upon the supposition that lightning surges entering over the primary conductors would pass to ground, and that the arrester would hold the primary winding to a potential equal to the arrester discharge voltage. Unhappily, this condition does not hold in practice because arrester ground resistances are not zero, but may be as high as several hundred ohms. Furthermore, the exposure of secondary circuits in urban districts may exceed by far the exposure of primary circuits there; hence lightning surges frequently enter on the secondary conductors when primary arresters connected in accordance with present practise are not in position to be of service.

From the foregoing it is clear that several factors may prevent the primary arresters from properly protecting the distribution circuits. Connecting the arrester ground to the grounded secondary neutral, however, appears to eliminate many of the disturbing factors. With such a connection the voltage between the transformer windings under impulse conditions will not exceed the potential allowed by

the arrester; this potential is low enough for transformer failures from bushing flashovers to be practically eliminated. With this idea in mind several investigations have been conducted in various parts of the country; 3 of these are covered in the following 3 articles. The first, by Opsahl, Brooks, and Southgate, includes a theoretical study and laboratory tests made to determine the effectiveness of interconnecting in different ways the primary arrester ground and the secondary neutral. The second article, by Harding and Sprague, covers tests made on an experimental line built in accordance with standard construction practise of the Commonwealth Edison Company of Chicago. The third article, by McEachron and Saxon, describes tests made on an actual distribution line built to serve a small rural community in central New York.

From the investigations conducted, the information presented in these articles indicates that much greater protection to distribution transformers is effected through interconnecting the primary arrester ground with the grounded secondary neutral than through present protection schemes. Further, it is shown that this interconnection introduces no additional hazard in the low voltage circuit except where the secondary neutral ground resistance is high.

I—Theoretical Studies and Laboratory Tests

By

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TESTS show that when a surge is applied to the primary of a distribution transformer that has a secondary ground, the isolated case will assume a low electrostatic potential above ground so that about from 80 to 95 per cent of the surge voltage will appear from primary lead to case. For simplicity in the considerations that follow, it will be assumed that the case potential under these conditions is the same as that of the secondary neutral.

Potential across a transformer when a surge is applied, as shown in Fig. 1, is the total of 3 components: the IR drop across the ground, the inductive drop across the ground lead, and the voltage across the arrester. The IR drop across the ground is proportional to the current in the surge, while the drop across the lead is proportional to the rate of rise of current. For anticipated surge currents the voltage across the ground alone can exceed the voltage across the arrester, unless the ground resistance is very low.

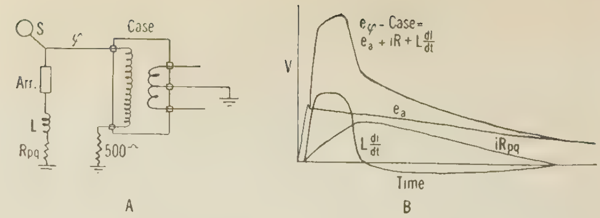


Fig. 1. Lightning surge voltage across the bushings of a distribution transformer protected in accordance with present practise

With present methods of installation, voltages appearing across the primary bushings often are great enough to cause flashovers; the completed path for the surge current to ground usually is over the secondary bushings. The usual sequence of events during a flashover and the voltages which occur are shown in Fig. 2. Primary bushing flashover takes place at a time t_1, and secondary bushing flashover almost simultaneously at a time t_2. If the transformer be connected to the power circuit the flashover path will carry the power arc until the primary fuse opens the circuit. In service this is the path over which the arc burns usually are found. Under these conditions both the surge current and the power follow current flow through the secondary neutral ground, but operating experience indicates no serious trouble on the customer's property.

Interconnection of Primary Arrester Ground and Secondary Neutral

By interconnecting at the transformer the arrester ground and the transformer secondary neutral, the potential difference across the primary bushings of the transformer will be limited to the voltage permitted by the arrester alone during a discharge, in accordance with the prior assumption that the secondary neutral and case remain at the same potential. In Fig. 3 is shown the effect of this interconnection where the assumed secondary neutral impedance to ground is small. Whether this secondary impedance be low or high, the potential across the primary bushing will not be greater than that permitted by the arrester alone. Under these conditions the transformer will not flash over and there will be no power current flowing from the primary circuit into the secondary neutral. Whatever impedance drop there is from the surge current flowing in the secondary neutral of course will appear as voltage in that circuit.

If a solid connection is not permissible between the secondary neutral and the ground terminal of the primary arrester, a gap or valve arrester of low voltage rating may be placed in the interconnection

Based upon "Lightning Protection for Distribution Transformers" (No. 32-18) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

s shown in Fig. 4A. This arrester will begin passing urrent when the voltage across the ground lead ecomes great enough to discharge the arrester. n this case the voltage across the primary bushing the sum of the voltages appearing across the priiary and interconnecting arresters as shown in ig. 4B. This connection will isolate effectively the rrester ground and the secondary neutral, as there no potential difference between them except during surge discharge.

A second method of obtaining the improved proection afforded by the interconnection without onnecting a solid conductor between the arrester round and the secondary neutral, is that shown in ig. 5. Where the effective leakage reactance etween the 2 halves of the secondary winding is

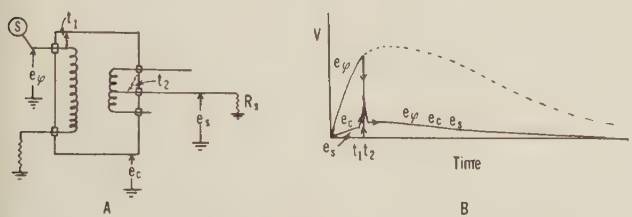


Fig. 2. Voltage-time relation as a flashover occurs on a distribution transformer from a surge applied to the primary

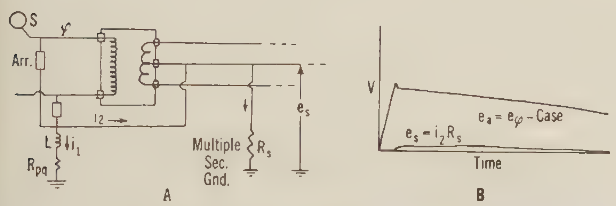


Fig. 3. Voltage across transformer bushings with primary arrester ground lead interconnected to secondary neutral; surge applied to primary

mall, the surge current in flowing as indicated will esult in a low voltage across the winding as the iagnetic effects of the 2 currents are in opposition. This circuit was proposed by C. B. Wright of the)uquesne Light Company (Pittsburgh, Pa.) and has hown very promising results in laboratory tests.

At present the safety code in most localities forbids ne interconnection of the primary arrester and the econdary neutral grounds. This regulation was iade in recognition of the fact that when a surge urrent flows through a ground a surge voltage ppears across it. The driven grounds which were ssumed when the regulation was adopted usually ave a much higher resistance than the water pipe rounds ordinarily used at the present time.

IMITATIONS OF THE INTERCONNECTION

Where both primary arrester and secondary eutral grounds are driven grounds, as in the case of rural customer, the interconnection can prevent ashover across the transformer insulation, but an ppreciable surge voltage may appear from secondary to ground. This condition is less serious than permitting a power fault in the secondary circuit, but the resistance of both grounds should be made as low as possible so that the surge *IR* drop may be low.

The ungrounded secondary is not common practise in distribution circuits; where it is used, a surge on the transformer primary will give the secondary circuit a potential above ground and the smaller the capacity of the secondary to ground, the greater will be its potential. Obviously an interconnection of a poor primary ground with the free secondary will not lower the voltage across the arrester ground appreciably, and flashovers from secondary to ground would be expected.

TESTS ON A TYPICAL DISTRIBUTION CIRCUIT

To determine the magnitude of the effects required to cause flashovers similar to those that have occurred in service, a program of tests was carried through. A diagram of the test circuit is shown in Fig. 6. The distribution transformer shown was mounted on a 35-ft pole. A ground lead was provided down the pole and in order to obtain low ground resistance, 2 ground rods were driven at the foot of the pole. The secondary wires were racked for about 140 ft. From the transformer pole and from the end of the secondary rack triplex services were run to a point on the ground where the neutral wires were solidly grounded. One wire of each triplex service was left open, as indicated in Fig. 6 by "open service." One service wire and the neutral from each service were connected to a 100-ft section of 2-conductor metal-armored BX cable, both ends of the armor being grounded. The 2 sections of BX cable were connected to the same 2 secondary wires.

In the tests as made, flashovers were necessary in order to simulate conditions that obtain in practise.

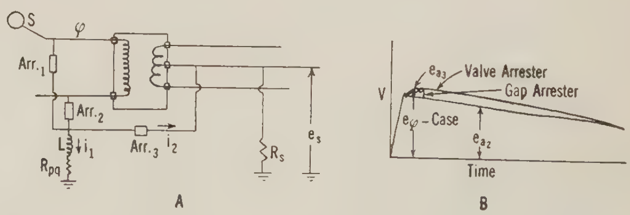


Fig. 4. Surge voltages across transformer bushings with primary arrester ground connected to secondary neutral through low voltage arrester; surge applied to primary

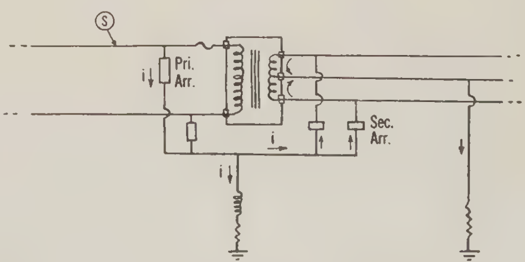


Fig. 5. Primary arrester ground connected to transformer secondary leads through secondary arresters; surge applied to primary

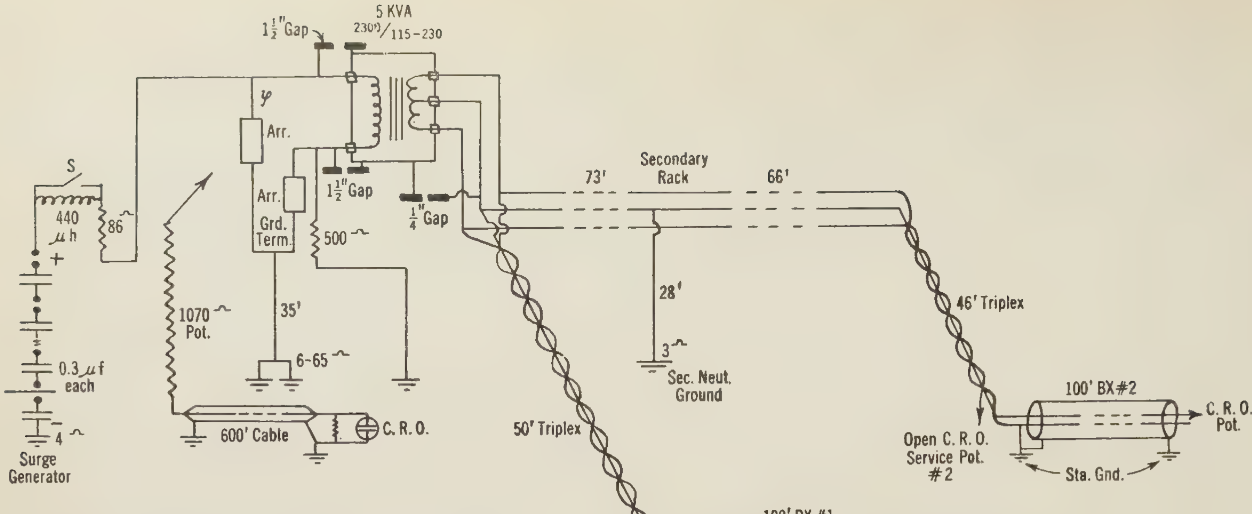


Fig. 6. Schematic diagram of test circuit. C.R.O. denotes cathode ray oscillograph connection

To secure consistent flashovers, gaps were placed around the primary and secondary bushings as shown in Fig. 21. A 500-ohm resistor was connected between the primary neutral and ground to simulate the effect of an uncharged conductor.

Arresters used in these tests were 3-kv autovalve arresters of the disk and mica spacer type. This type of arrester was selected rather than the porous block type because many of them are in service and because the tests were laid out to duplicate service conditions as closely as possible. Upon test, this type of arrester was found to have a maximum crest voltage of 15 kv across its terminals during a surge discharge of 800 amp.

Most of the oscillograms have been replotted to the same scale to show more readily the relative voltage-time values; a few of these are shown in Figs. 7 to 12, inclusive. Crest voltages measured at certain points for the various circuit connections and for each of the 2 types of impulse wave used are given in Table I.

Voltages at the transformer were measured by means of a cathode ray oscillograph connected to a 1,070-ohm resistance potentiometer through a delay cable. Voltages at the secondary service terminals were measured by a 5,100-ohm resistance potentiometer. These potentiometers of course have some effect on the surge voltages.

Effect of the Ground Lead on Protection

To show the effect of the inductance of the arrester ground lead on the voltage appearing across the primary bushing, 2 rates of current rise were selected. The "slow" rate of current rise was produced by introducing the 400-microhenry inductance into the circuit of the surge generator (Fig. 6). The steep front surge rose to a maximum of 1,200 amp in 2 microseconds, while the slow front surge rose to 900 amp in 9 microseconds. Successive test surges were found to be practically identical.

With the surge generator set to give a current wave of fast front and a crest of slightly less than 1,200 amp in order to prevent flashover of the transformer gaps, the oscillograms shown in Fig. 7 were taken. In Fig. 8 are plotted oscillograms obtained using the slow front surge with no gap flashovers and with standard connections. Crest voltages for these tests are listed in Table I. These tests indicate that after an initial disturbance determined by the surge impedance of the ground lead, the voltage across the ground lead is determined by the lead inductance and the rate of change of current. The initial disturbance is due in part to the type of surge circuit used.

At the 1,200-amp surge generator setting the transformer gaps flashed over at 50 kv from line to ground; in Fig. 9 are plotted voltage oscillograms so

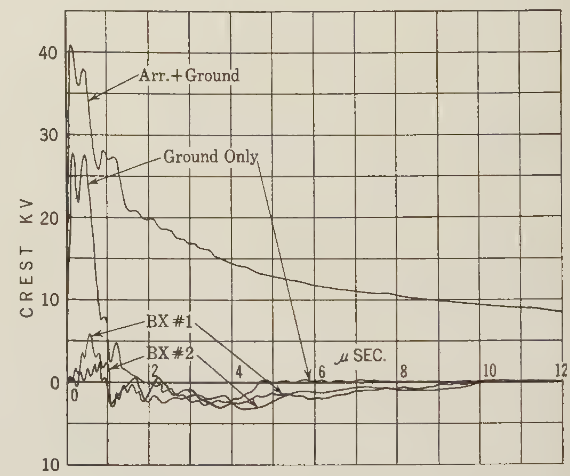


Fig. 7. Voltages measured in circuit of Fig. 6 with steep front surge of reduced magnitude

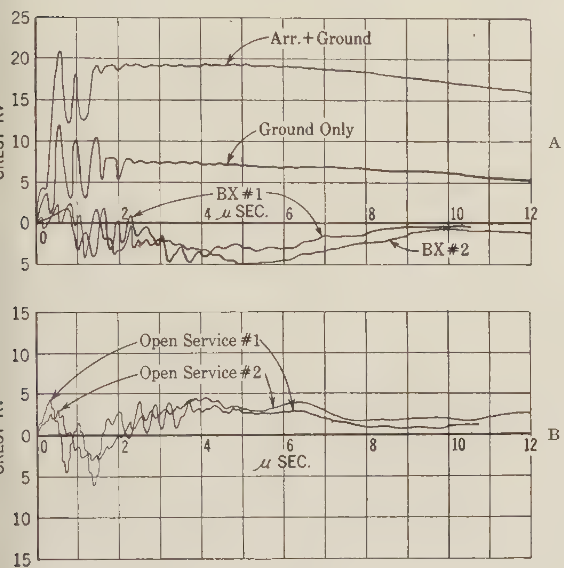
The gaps may have flashed accidentally during the oscillographic measurement of the voltage across the arrester lead plus ground, since the lack of sustained voltage seems incompatible with the given values of current and ground resistance, and also because the difference between the arrester-plus-ground and the arrester-lead-plus-ground voltages is greater than the arrester voltage, 15 kv. This curve is almost identical with the corresponding curve in Fig. 9

btained. As before, the crest voltages are listed in 'able I. The voltage across open service No. 2 was 3 kv compared to 24 kv across BX No. 2, showing ne attenuating effect of the BX cable on the surge.

'ests With Arrester Ground and Secondary Neutral Interconnected

In Fig. 10 are plotted oscillograms taken when the rrester ground terminal and secondary neutral were nterconnected. No gap flashovers took place. As nay be seen, the difference in potential between the hase lead and the secondary neutral does not exceed 15 kv, the voltage permitted by the arrester alone. A comparison of columns 3 and 4 of Table I indicates that the crest secondary voltages are about the same with the interconnection as they are during a flashover of the transformer gaps without the interconnection.

The extreme case of high arrester ground resistance is that of no ground at all. Obviously with no ground the arrester could not discharge and any surge above 50-kv crest would flash over the transformer gaps. Under such conditions, protection for the transformer can be obtained by connecting the arrester ground terminal to the secondary neu-



Surge voltages measured in the circuit of Fig. 6.

Fig. 8 A and B. (Left) Slow front surge with no transformer gap flashovers

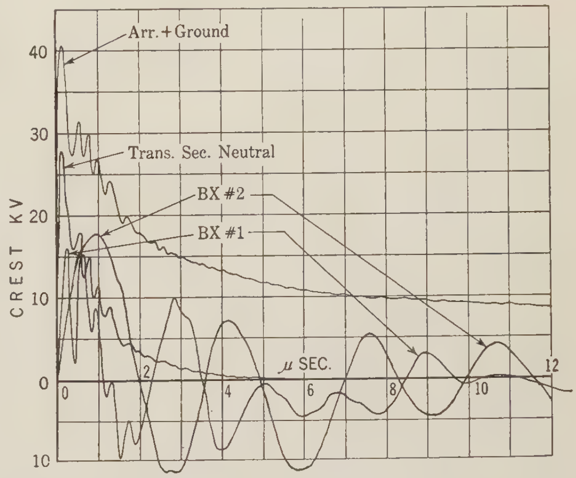


Fig. 10. (Right) Steep front surge with arrester ground and secondary neutral interconnected; no transformer gap flashovers

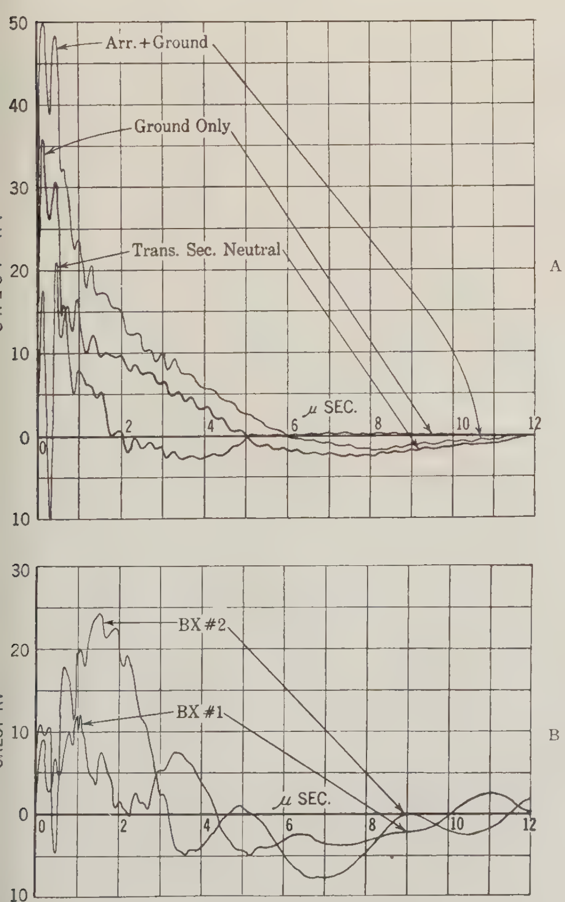


Fig. 9 A and B. (Left) Steep front surge with transformer gaps flashing over

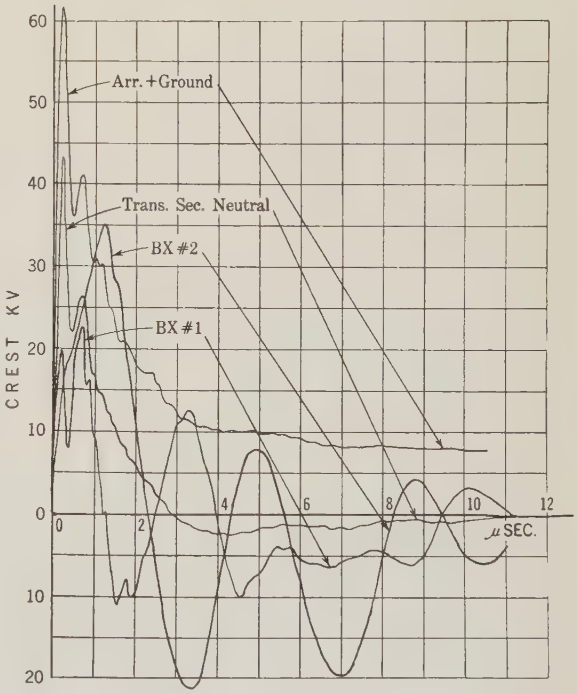


Fig. 11. (Right) Steep front surge with primary arresters not grounded at the transformer but connected to secondary neutral only; no transformer gap flashovers

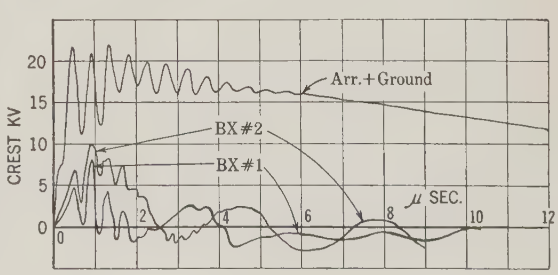


Fig. 12. (Right) Slow front surge with primary arresters not grounded at the transformer but connected to secondary neutral; no transformer gap flashovers

Table I—Crest Voltage Measurements

Column 1	2	3	4	5	6	7	8
	Steep Front Surge				Slow Front Surge		
Point of Voltage Measurement*	Standard Connection: Gaps Not Flashing	Standard Connection: Gaps Flashing	Arr. Ground and Secondary Neutral Interconnected	Arrester Ground to Secondary Neutral Only	Standard Connection Gaps Not Flashing	Arrester Ground to Secondary Neutral Only	Arrester Grounded as in Fig. 5
Arrester plus ground	+41 kv	+50 kv	+41 kv	+62 kv	+21 kv	+21 kv	+21 kv.
Arrester ground lead	+28	+36			+12		
Trans. sec. neutral		+20	+28	+43			
Open Service No. 1	+ 3	+25	+20	+35	+ 3		
BX No. 1	− 3	+12	+16	+23	− 4	+ 8	+14
Open Service No. 2	+ 3	+33	+34	+56	+ 4		
BX No. 2	− 3	+24	+18	+35	− 5	+10	+19
Oscillograms plotted	Fig. 7	Fig. 9	Fig. 10	Fig. 11	Fig. 8	Fig. 12	—

* All voltage measurements were made by resistance potentiometers and cathode ray oscillographs.

tral. To investigate this the circuit of Fig. 6 was modified by connecting the ground terminals of the primary arresters to the secondary neutral only. Under such conditions the full surge current flows to ground through the transformer secondary neutral wire. Figs. 11 and 12, respectively, show the voltages measured with steep front and slow front surges. In neither case did the transformer gaps flash over, as the voltage across the transformer bushings was limited by the arrester to about 15 kv. The maximum voltage to ground with the fast surge was 60 kv, which was considerably above the gap flashover voltage.

A test was made to investigate the effects of the indirect interconnection of the secondary neutral and arrester ground, using the circuit shown in Fig. 5 except that the separate arrester ground was omitted so that the only path for the arrester surge current was through the secondary arresters, secondary windings, and secondary neutral to ground. Crest voltages for this test are shown in Table I column 8. A comparison of columns 7 and 8 of Table I shows that the leakage reactance between the 2 secondary windings of this transformer evidently was high enough to increase the voltage appearing across the service wires. This same circuit was tested with the steep-front surge. The voltage was sufficiently great to cause a flashover in the BX cable, so no measurement was made; however, no flashover occurred on the transformer gaps.

Surge Voltages Appearing on the Secondary

A surge voltage impressed across the primary of a distribution transformer will induce a voltage across the secondary; this voltage has a duration about the same as that of the primary voltage. A rapidly changing surge current passing to ground over the secondary neutral produces an oscillatory voltage between the outside wires and ground at the service terminals, the maximum value of which is about the same as that of the transformer neutral to ground at the transformer. However, the voltage on the BX cable (Fig. 6) is lower than that on the corresponding open service; and the voltage on the more distant service, No. 2, is greater than that on service No. 1.

Voltages appearing at the services when the arrester ground and secondary neutral are interconnected are about the same as those appearing when a steep-front surge causes the transformer gaps to flash over due to the inductive drop in the arrester ground lead.

Secondary voltages with the arrester ground and secondary neutral interconnected, though of short duration, appear to be of rather high magnitude. While the secondary voltages with this circuit may be compared with corresponding voltages on the other circuits tested, it should be noted that the length of racked secondary was short as compared with lengths usually found in practise, and that voltages on an actual distribution system probably will be lower. Voltages of the relative magnitudes tabulated in column 3 of Table I appear now without serious effect for transformer flashovers where the ground resistance is low.

Conclusions

Tests show that when a transformer is subjected to a lightning surge the case will assume a potential of about 10 per cent of that appearing between the primary leads and secondary neutral. Neglecting the potential of the case the voltage across the transformer bushings is the sum of the voltages across the arrester, the arrester ground lead, and the arrester ground resistance. With a surge of steep front the inductive voltage across the ground lead alone may exceed the arrester voltage. Remedial steps which can be taken are limited to a reduction of the arrester ground resistance and of the inductive drop across the ground lead. Practical application of these measures is limited by field conditions.

Improved protection of a distribution transformer may be secured by any one of several methods of connecting the arrester ground lead to the secondary circuit. The following methods will limit the surge voltage across the bushings to approximately the characteristic crest voltage of the primary arrester, but will differ in resulting secondary voltages:

1. Direct connection of a low resistance primary arrester ground to a grounded secondary neutral produces no higher voltages at the customer's service than are experienced when flashover occurs with present protection schemes.

2. Direct connection of a high resistance primary arrester ground to a grounded secondary neutral results in higher surge voltages appearing on the customer's leads than when the ground resistance is low.

3. Connecting the primary arrester ground to the secondary neutral

ırough a low voltage arrester gives substantially the same results
; the direct connection.

Connecting the primary arrester ground to the secondary outside ires through 2 low voltage arresters results in increased surge voltge at the service

I—Tests on a Typical Urban Circuit

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Both of Purdue University, Lafayette, Ind.

UNDER a cooperative arrangement vith the Utilities Research Commission of Chicago, he engineering experiment station at Purdue Uniersity has been conducting an investigation of surge rotection for distribution circuits. Many of the ests have involved the interconnection of the prinary lightning arrester ground and the grounded ieutral of the secondary main; it is this phase of the vork which will be treated in this article.

After some preliminary work, a 5-span distribution ine was constructed, over which was supported an nsulated artificial cloud for the purpose of inducing urge potentials in the distribution system. The listribution line was of the double-crossarm woodoole type with 4 4,000-volt primaries on the upper rm and 6 secondaries on the lower arm, the latter omprising a 3-phase, 230-volt power circuit and a ingle-phase 115/230-volt lighting circuit (see Fig. 5). The line was built in accordance with the tandard construction practise of the Commonvealth Edison Company of Chicago. A bank of distribution transformers and a customer's service vere included in the distribution system but were not onnected to any 60-cycle supply. Circuit grounds vere made on the customer's service and on the listribution system as in standard practise. (See ig. 13 for circuit diagram.)

Potentials Induced on Line Wires

The cloud normally was held at ground potential y means of a high resistance leak. At definite ntervals a surge generator was made to discharge nto the cloud, thereby causing a sudden change in loud potential with consequent induced voltages in he distribution system. These induced voltages vere measured by a sphere gap at the transformers nd at the customer's service entrance.

ased upon "Interconnection of Primary Lightning Arrester Ground and the rounded Neutral of the Secondary Main" (No. 32-16) presented at the A.I.E.E. inter convention, New York, N. Y., Jan. 25–29, 1932. Revised especially for LECTRICAL ENGINEERING and brought up to date.

A series of tests was made in which the induced voltages to ground were measured as the distribution system was built up step-by-step, that is, by starting with the wires only and adding the circuit grounds, arresters, transformer windings, etc., until the system was complete. In Fig. 14 is shown graphically the change in the magnitude of induced voltages during this procedure, and also the system voltages with and without the interconnection of the secondary neutral to the primary arrester ground.

In general, Fig. 14 is self-explanatory, but it is desired to call attention to some of the more interesting changes in the induced voltages and their causes. As noted in the legend, the first vertical line of each group represents the induced voltages on that particular wire with no grounds or connected apparatus. Potentials induced on the primary wires (between wires 1 and 4 and ground) were approximately 90 kv; on the secondary wires (between wires 5, 8, 9, and ground) approximately 75 kv. (See Fig. 15 for positions of wires on crossarms.) In test 2 of each group, wire No. 9 (secondary neutral) was connected to a driven pipe ground of approximately 15 ohms resistance, one span distant from the transformer bank. Aside from the reduction in voltage on wire No. 9, itself, it is interesting to note the reduction on wires 4 and 8, adjacent to wire No. 9.

Test 3 of each group indicates the voltages with the further addition of primary phase and neutral arresters. As would be expected, there was a marked decrease in the potentials of all primary wires. There occurred also a decided reduction in

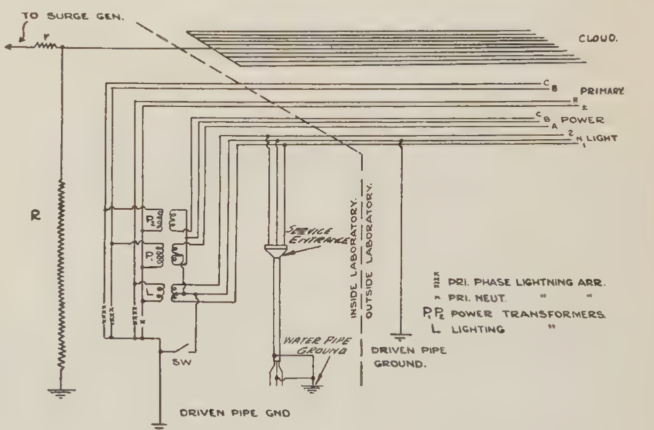


Fig. 13. Circuit diagram of experimental distribution system and artificial cloud

the potentials of the secondary wires (wires 5, 8, 9) due to the shielding effect of the primary wires after the arresters had broken down. This is particularly significant and important for it indicates that in the field a well protected primary system provides considerable protection for secondaries located below the primaries.

In Test 4, connecting the transformer primary windings caused but slight reduction in induced potentials, showing that the primary winding presents a relatively high impedance to the surge. With transformers, house-wiring circuit, and all grounds connected to the circuit, as in Fig. 13, voltages to

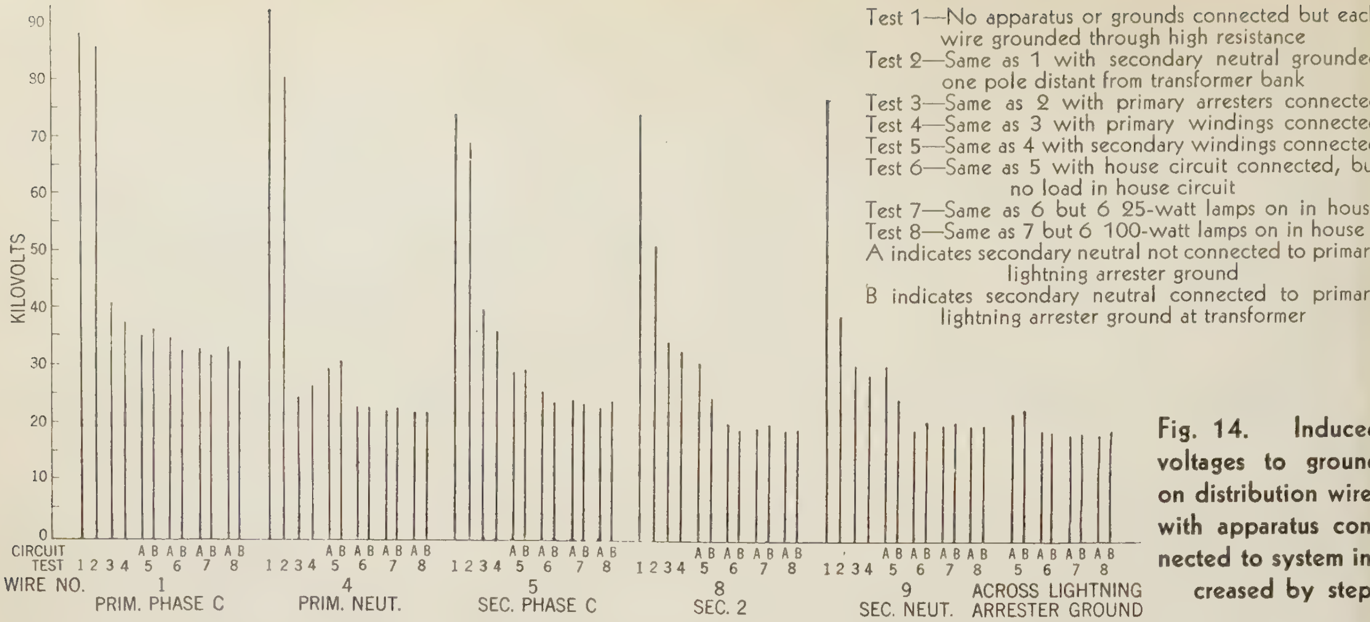


Fig. 14. Induced voltages to ground on distribution wires with apparatus connected to system increased by steps

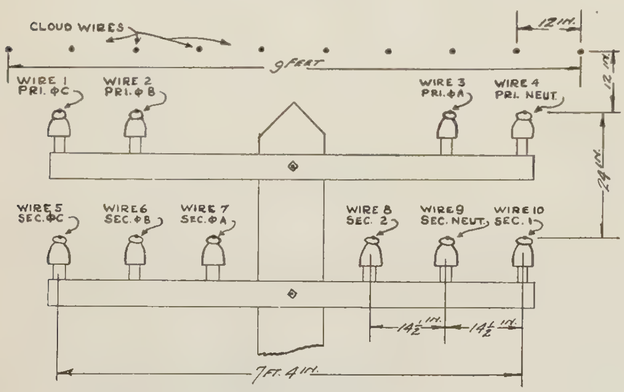


Fig. 15. Arrangement of artificial cloud and line wires

ground on the power and lighting secondaries and on the primary neutral were of the order of 20 to 25 kv while those between the primary phase wires and ground were of the order of 30 to 35 kv.

Potentials Induced in Transformer Windings

With regard to voltages across transformer windings it was determined that for a single-phase lighting transformer with its secondary neutral grounded, the voltage across the secondary winding was approximately 5 to 15 per cent of that across the primary winding. With 3-phase 230-volt Δ-connected power secondary windings having the midpoint of one winding grounded to the lighting secondary neutral, it was determined that the voltages across the secondary coils were approximately 20 to 80 per cent of those across the primary windings. In both cases the induced potentials overstress the secondary insulation without exceeding the safe limit on the primary insulation. A solution of this difficulty is of course to increase the insulation of the secondary winding. In so doing, however, capacitances between primary, secondary, and core will be changed; therefore consideration should be given to the redistribution of potentials resulting therefrom. These are relatively inexpensive additions to the design and construction of the transformer.

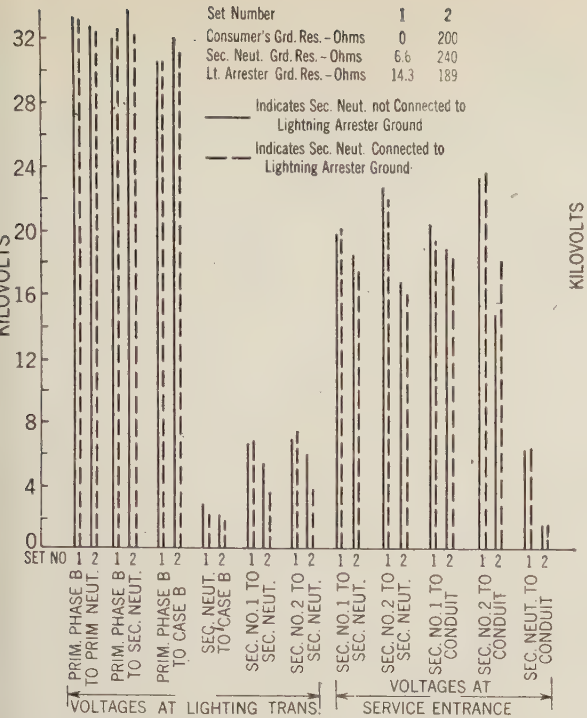
In the preceding group of tests interconnecting the secondary neutral and the lightning arrester ground caused, in general, approximately 5 per cent decrease in magnitude of the induced voltages to ground. The tests indicated, however, that the effect of this connection depends to a large extent upon such factors as the steepness of wave front of the surge, and time lag of the primary arresters; hence, under the test conditions of induced potentials and arrester currents of small magnitudes, it cannot be said that this connection *always* is beneficial.

Tests With Different Ground Resistances

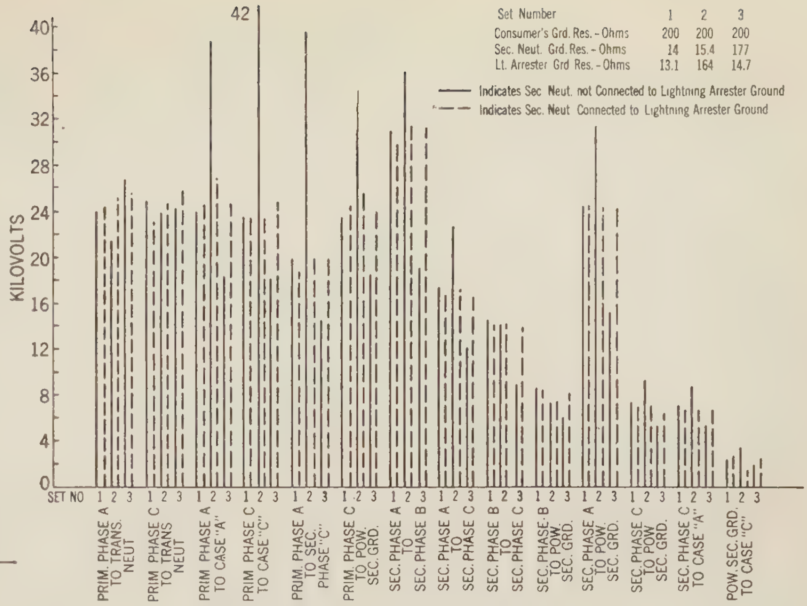
Induced voltages measured at the transformers and at the service entrance under various conditions of ground resistance are shown graphically in Figs. 16 and 17. Tests were made both with and without interconnection of the secondary neutral to the primary lightning arrester ground. In several instances the interconnection caused a marked decrease in the voltage between primary phase wire and secondary ground.

Field investigations have demonstrated that many transformer failures and blown fuses have been caused by flashover from a primary phase lead to the transformer case and thence to the secondary neutral. In fact, operating companies have reported that in about $^{3}/_{4}$ of the transformer failures on distribution systems due to lightning, the damage involved both the primary and secondary windings.

Measurements of induced voltages between primary phase lead and secondary neutral have shown that the interconnection of the secondary neutral with the lightning arrester ground in general is beneficial to the transformer. In particular, with a low resistance secondary neutral ground and a high resistance lightning arrester ground, the interconnection reduced this voltage by 30 to 50 per cent. (See Fig. 17, set 2.) With no interconnection and with a high resistance secondary neutral ground and low resistance lightning arrester ground, the voltage between primary phase lead and secondary winding



Secondary neutral ground one span from transformer pole



Secondary neutral ground at transformer pole

Fig. 16 (left) and 17 (right). Effect of interconnection upon the potentials at the transformers and at the service entrance with various ground resistances

vas somewhat reduced at the expense of an increased voltage across the high resistance secondary neutral ground. By making the interconnection and thereby connecting the low resistance lightning arrester ground in parallel with the high resistance secondary ground, there was a redistribution of voltage so that he potential between primary phase lead and econdary neutral was approximately the same as vhen using the interconnection and with low seconlary neutral ground resistance and high lightning arrester ground resistance. (See Fig. 17, set 3.)

Potentials at Service

As indicated by Fig. 18, the tests showed that due o making the interconnection there was a 10 per cent reduction in the potentials at the service entrance. There is indicated also a marked reduction n the voltages at the service entrance when the customer's lamps were turned on. This seems to be an argument in favor of turning on the lamps during a thunderstorm.

During the latter part of the work the transformers vere mounted on one of the poles and a testing shelter was constructed on poles immediately adjacent to the transformer pole. The induced potentials were slightly higher, but otherwise in good general agreement with those obtained when the transformers were on the laboratory floor. The majority of the tests covered here have been made with the transformers on the poles.

Subsequent to the preparation of the paper presented at the winter convention in New York, tests have been made with the surge generator discharging directly from the cloud into a primary phase wire, giving arrester currents up to 2,000 amp. Under these conditions, the beneficial effect of the interconnection was much more pronounced. Whereas with secondary neutral ground resistances of from 10 to 15 ohms and arrester ground resistances of from 100 to 200 ohms, the transformer bushings repeatedly flashed over, it was found that the interconnection in all cases prevented flashover and reduced the potentials across the transformer to approximately 35 kv.

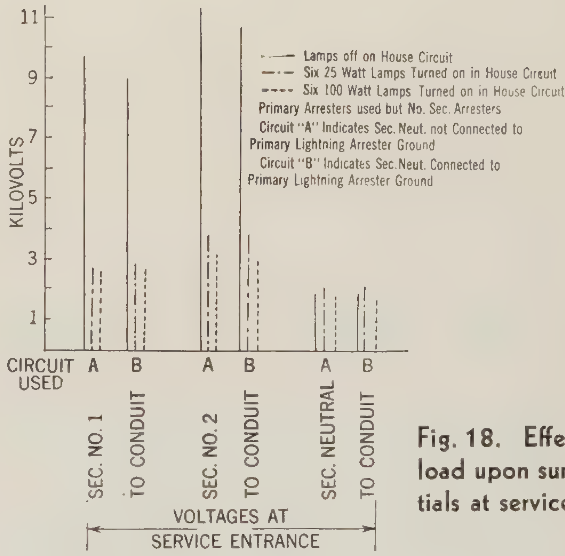


Fig. 18. Effect of lamp load upon surge potentials at service entrance

Laboratory surge tests were made on several of the newer surge-proof distribution transformers and also on some rather old and dirt-covered transformers which had seen considerable service. With a lightning arrester operating normally and connected between primary phase and secondary neutral (equivalent to the interconnection) none of the transformers showed any signs of failure.

While in no way depreciating the advantages of the present surge-proof type, this would indicate that increased service and reliability may be obtained from some of the old style transformers if the interconnection is adopted.

Surge tests on the primary bushings of some surge-proof type transformers indicate that well over 100 kv is required to flash over the bushing, due primarily to several layers of cambric tape on the phase lead. In case of possible arrester failure it is evident that the winding insulation may be subjected to abnormally high stress without relief by bushing flashover.

Conclusions

From the results obtained in this investigation, the following conclusions seem justified:

1. The value of an experimental wood pole distribution line with an insulated artificial cloud charged by a surge generator was established definitely for lightning protective investigations involving induced as well as direct stroke potentials.

2. The tests demonstrated the practicability and economy of studying, by means of such equipment, the operation of various transformer, lightning arrester, and ground connections, when exposed to surges approximating those of lightning.

3. Efficient primary protection on an overhead distribution line affords considerable protection to secondaries located below the primaries.

4. A well grounded secondary neutral wire reduces potentials on adjacent wires.

5. In existing transformer design the insulation of the secondary winding may be overstressed by steep wave front surges without excessive stress on the primary insulation; such stresses may be relieved by improvements in secondary insulation.

6. Low ground resistances, although desirable in other respects, do not necessarily reduce the initial potentials which may be induced on the system.

7. A non-inductive load in the consumer's premises reduces the potentials 60 to 70 per cent at the service entrance.

8. Interconnecting the primary lightning arrester ground to the grounded neutral of the secondary main greatly reduces the voltages at the transformer and imposes no extra hazard upon the consumer's wiring. Specific cases of this conclusion are covered in the following 4 paragraphs.

9. With the lightning arrester ground resistance and secondary neutral ground resistance below 20 ohms, the interconnection has but little effect upon the magnitudes of induced potentials at the transformer.

10. With an arrester ground of from 100 to 200 ohms and a secondary neutral ground of less than 20 ohms, the interconnection reduces by from 30 to 50 per cent potentials across the transformer terminals.

11. With a lightning arrester ground of less than 20 ohms, and a secondary neutral ground of from 100 to 200 ohms (an unusual combination), the potentials across the transformer terminals were increased about 25 per cent by making the interconnection.

12. With secondary neutral and primary arrester ground resistances both ranging from 100 to 200 ohms, the interconnection had practically no effect upon the magnitudes of the voltages at the transformer.

13. Using "direct strokes" from the surge generator, the interconnection is of great benefit with high arrester ground resistances. With any combination of secondary-neutral and arrester ground resistances, the interconnection limits the transformer stress to the value determined by the arrester voltage, and should reduce materially the lightning failures on non-surge-proof types of transformers.

14. With usual city conditions, consisting of a multiplicity of low resistance grounds on the secondary neutral, and the further possibility in some instances of a lightning arrester ground of high resistance, it has been demonstrated herein that potentials at the transformer may be reduced greatly by the interconnection of the primary lightning arrester ground and the grounded neutral of the secondary main.

III—Tests on a Typical Rural Circuit

By

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THERE HAS BEEN a growing conviction on the part of those closely associated with the problem of protection that in practise the present method of lightning arrester application on distribution systems involves too many uncontrollable factors. Connecting the primary arrester ground to the grounded secondary neutral appears to eliminate many of the uncontrollable factors. With such a connection the voltage between transformer windings under impulse conditions will not exceed the potential allowed by the arrester; this potential is so low that bushing flashovers or transformer failures should be practically eliminated. In proposing this the question naturally arises: Will such a connection introduce any additional hazard on the customer's premises and will it offer the advantage from the protection standpoint that apparently it should? Experience in those cases where this interconnection has been tried does not indicate any increased hazard, and the protection record seems to be far above that of the present connection.

In order that experimental data might be obtained under controlled test conditions, the General Electric Company conducted a field investigation in cooperation with the Associated Gas and Electric Company. The tests were made on a single-phase 4,600-volt rural line of the New York State Electric and Gas Company, built to serve the village of Willseyville, N. Y., and the surrounding community. The line had just been constructed at the time the tests were made and for most of the power tests was energized at 2,300 volts. A portable million volt impulse generator and a cathode ray oscillograph were used in the tests. A positive impulse voltage of 350 kv applied resulted in a 6/14 microsec wave with a crest of 123 kv at the test transformer location 4.45 miles away. To prevent flashover, it was necessary to increase materially the insulation at most of the guyed poles.

A 10-kva 2,300–115/230-volt transformer was mounted about 30 ft above ground on the pole at which the primary conductors terminated. The 3 secondary conductors X_1, X_{23}, and X_4 extended from this pole into the village of Willseyville, having a total circuit length of 3,273 ft located on 4 streets. (See Fig. 19.) A building which will be designated

Based upon "Lightning Protection for Distribution Transformers" (No. 32-17) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932. Revised especially for Electrical Engineering and brought up to date.

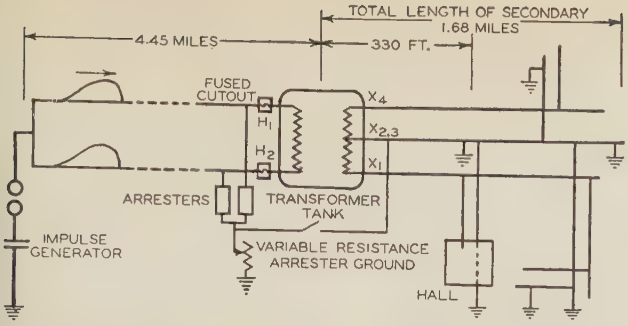


Fig. 19. Circuit connections for protection tests on transformers

; the "hall" was connected between X_1 and X_{23} : a point about 400 ft from the transformer pole. his building was the only one connected to the condary circuits during the tests. In addition to e 65-ohm ground at the hall the secondary neutral as grounded at 5 points, the nearest being about 30 ft from the transformer pole. The combined sistance of all secondary grounds was 25 ohms.

The hall was wired with metallic armored cable 3X); the measured capacitance between 1 wire ıd ground was 0.04 μf. The hall was provided ith 6 circuits and 26 outlets, the ground being ade to the casing of a driven well.

All cathode ray oscillograms to be shown registered ltages to ground. Voltages between windings are tained by subtraction, but were checked by direct easurements with sphere gaps. Resistance and ıpacitance dividers were used to reduce the potentials to proper values for the oscillograph deflectg plates. Most of the tests were made with 3- v pellet arresters which, according to laboratory sts, have a breakdown potential of about 17 kv ıd an IR drop of 6 to 7 kv. Some of the tests ere made with pellet arresters having higher ratgs.

IPULSE APPLIED TO THE PRIMARY

Only results with impulses on both primary conıctors will be given as this is the most representave condition of service and the conclusions drawn pply equally well whether the impulse is on 1 conıctor or both. Although nearly 1,000 oscillorams were taken, in the limited space available ıly a few of the data can be shown.

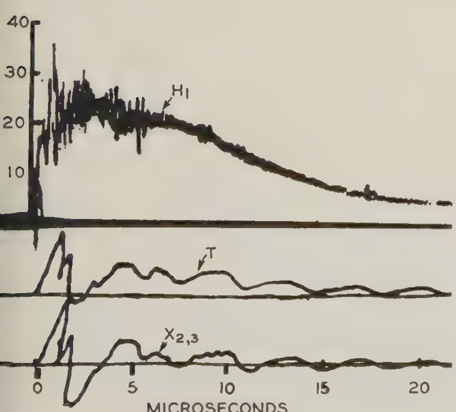
Oscillograms reproduced in Fig. 20 show the potential with respect to ground of the primary H_1, tank T, and secondary neutral X_{23} with the 3-kv primary arresters connected to a 10-ohm ground in the usual manner. The secondary neutral potential remains close to ground potential while the tank takes an intermediate potential, but close to the secondary. As a result, most of the potential allowed by the primary arrester and its ground is impressed from the primary to tank and secondary.

Increasing the arrester ground resistance to 60 ohms increases the primary potential to tank and secondary and also increases the tank potential, as shown in Fig. 21. It is clear that further increase in arrester ground resistance is likely to result in either flashover of the primary bushings or a winding failure. Flashover of both primary bushings, or cascade flashover of a primary and secondary bushing, if the primary is grounded, is likely to result in blown fuses.

Interconnecting the arrester ground and secondary neutral greatly reduces the potentials between windings and from winding to tank as shown in Fig. 22. With this connection the oscillograms show that the tank and secondary have practically the same potential, while the primary to secondary potential is only the arrester potential, although the arrester ground resistance was 60 ohms.

In Fig. 23 the oscillograms of Figs. 21 and 22 are subtracted to show the great reduction in potential between primary and secondary when the arrester and secondary neutral were interconnected. Additional tests show that there is little difference of potential between the different windings even with the arrester ground disconnected. (Fig. 24.) Thus, regardless of the arrester ground resistance the transformer is well protected and fuse blowing is reduced to a minimum by eliminating bushing arcover.

Tests made using 6-kv pellet arresters with and without the tank connected to the arrester ground, which had a resistance of 10 ohms, are shown in Fig. 25. The oscillograms are replotted as they were taken with different time scales. The impulse was applied to both primary conductors, the secondary conductors still being connected to the secondary distribution system. The results show that the connection of the tank to the arrester ground

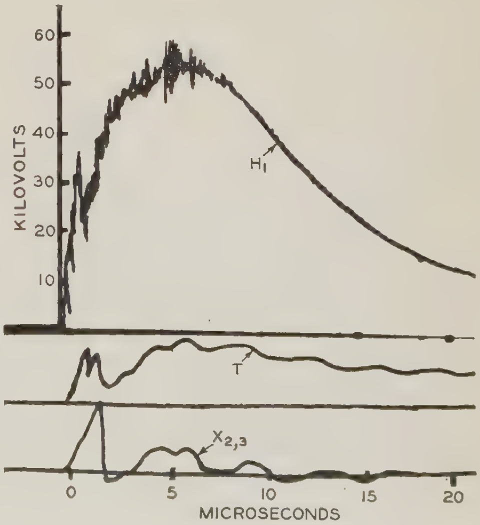


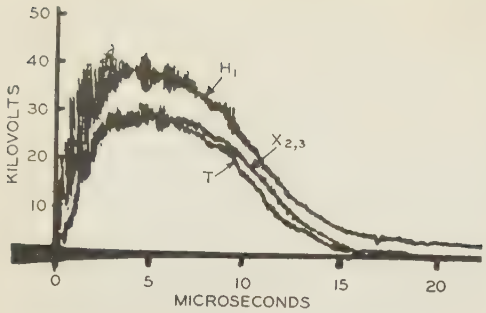
Potentials measured at the transformer when impulses were applied to the primary conductors. Primary lightning arresters grounded at the transformer pole in the usual manner

Fig. 20. (Left) Arrester ground resistance 10 ohms

Fig. 21. (Right) Arrester ground resistance 60 ohms

Oscillograms in each group have same calibration



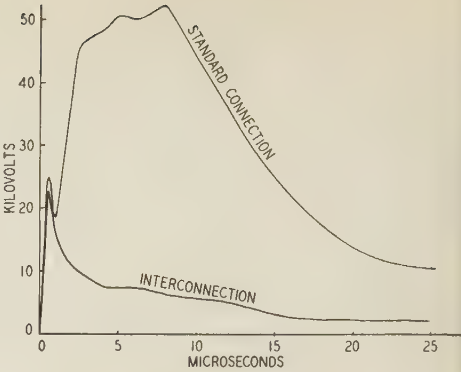


Arrester ground resistance 60 ohms

Fig. 22. (Left) Surge voltages at the transformer with primary arrester ground and secondary neutral interconnected, and impulses applied to primary

Fig. 23. (Right) Comparative voltages from transformer primary to secondary neutral

Primary arrester ground (1) connected in usual manner and (2) interconnected to secondary neutral; arrester ground resistance 60 ohms



lowers the potential between the primary and tank to the arrester voltage, but raises the potential between the tank and secondary to a value equal to the *IR* drop in the ground. Such connection does not lower the voltage between primary and secondary, and if the ground resistance is high, excess potentials will appear between the tank and secondary.

Impulse Applied to Secondary

In making this test the line conductors from the impulse generator were connected to the secondary wires X_1 and X_4, each of the primary leads of the transformer being connected to ground through a 500-ohm surge impedance. As in the previous tests the entire secondary distribution system was connected, but with no lights on at the hall. Results of these tests are presented in Figs. 26 and 27. With a secondary neutral ground resistance of 19 ohms and the primary arresters disconnected from ground, a high voltage was measured between primary and secondary (Fig. 26). This is reduced greatly by interconnecting the arrester ground and secondary neutral (Fig. 27) the same as in the case of an impulse on the primary. Thus the primary arrester with interconnection to the secondary neutral will keep the transformer windings at potentials differing only by the arrester potential, whether the impulse originates on primary or secondary. For extremely steep waves originating on the secondary, secondary protection between conductors and neutral may be needed.

Measurements at the Consumer's Service

Oscillograms were taken at the service in the hall during the protection tests; the maximum voltage was found to be 3.9 kv. At this potential sparking took place within fixtures which effectively limited the voltage. With the standard arrester connection on the transformer pole and an impulse of 123 kv applied to the primary, the potential between conductors at the hall was 400 and 880 volts when the arrester ground resistance was 10 and 60 ohms, respectively. When a gap between primary and secondary set for about 50 kv rms sparked, the hall wiring arced over at 3.9 kv. When the interconnection between primary arrester ground and secondary neutral was made the wiring arced over even with arrester ground resistances as low as 10 ohms.

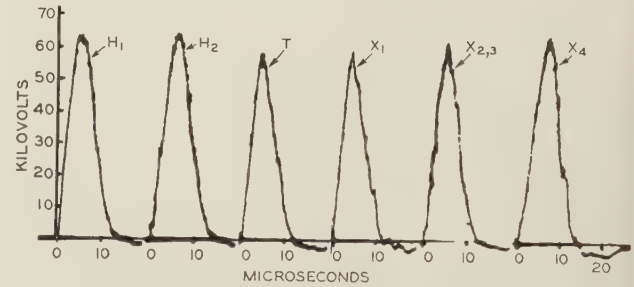


Fig. 24. Surge voltages at the transformer with primary arrester ground and secondary neutral interconnected, and arrester ground disconnected

With the arrester ground and secondary neutral interconnected and the arrester ground disconnected at the transformer pole, when an impulse was applied to the secondary conductors, the wiring arced over and a potential of 15 kv was measured to a separate ground at the hall. With a 100-watt lamp connected across the secondary, the potential between wires was reduced to 1.3 kv.

Power Tests: Isolated-Neutral Primary

Two transformers rated $1^1/_2$ kva which had blown fuses quite consistently during lightning storms were placed on the pole fused with 2 amp fuses. A 25-amp non-inductive load was connected to X_1 and X_4. The primary voltage was 4,600 non-grounded, which was obtained from a rural 6,900-volt single-phase line through the use of two 50-kva transformers rated 6,900/2,300 volts and 2,300/4,600 volts, respectively.

When impulses were applied to the primary conductors, the first transformer, which had low oil level, sparked over the terminal board with power follow; this blew the 2-amp fuse. With 6-kv pellet arresters connected and ground resistances up to 170 ohms the terminal board did not flash and of course the fuses did not blow. The oil level was raised, arrester disconnected, and 10 impulses applied, which arced to the tank over both the primary and secondary leads. No power follow took place, which was to be expected since the power source was not grounded.

The second transformer did not arc over even with arrester ground resistances as high as 170 ohms. The arresters then were removed and both high voltage bushings arced over to the tank. Al-

ıough 10 impulses were applied, some with and ɔme without secondary 28-amp load, the primary -amp fuses did not blow. A more intense discharge, ɔwever, might have started the power follow.

During the tests with the primary ungrounded scillographic measurements at the hall showed no ıcrease in power voltage either between wires or ɔ ground. Likewise with the same power source ıe interconnection of arrester ground and seconary neutral did not affect the power voltage at ıe hall during the period of arrester operation.

ower Tests: Grounded Primary

In these tests, the 10-kva transformer on the ɔle was connected to the secondary distribution ystem its primary receiving power over the experiıental line at 2,300 volts from one of the 50-kva ansformers connected to the 6,900-volt rural line. or the tests to be described one conductor was rounded through a 35-ohm ground at the 50-kva ansformer, to simulate one leg of a 2,300/4,000-olt grounded-neutral system.

First, a $^3/_4$-in. gap was connected between the rimary phase wire and the secondary neutral; impulses out of 5 blew the 2-amp fuse on power ɔllow, and a voltage of between 600 and 750 volts fective was measured at the hall between conducɔrs and a separate ground for times up to about $/_2$ sec until the fuse cleared the circuit. With a ɔwer resistance ground at the power source the voltage measured at the hall would have been higher but the duration shorter.

With the 3-kva arrester disconnected from ground at the transformer pole, but interconnected to the secondary neutral, a voltage of 101 volts rms was measured for a fraction of 1 cycle. The secondary neutral ground was 25 ohms and the primary ground at the 50-kva transformer, 35 ohms.

When the primary arresters were connected to a 10-ohm ground at the transformer pole the potential of the conductors at the hall to a separate ground was 33 volts rms for a fraction of a cycle. Another test was made in which the sheath of the *BX* conduit in the hall was connected to a separate ground from that of the grounded conductor within the conduit. With the interconnection, and an arrester ground of 10 ohms at the transformer pole and secondary neutral ground of 25 ohms, no 60-cycle potential could be measured from the sheath to a separate ground, although the sheath ground was of the order of 1,000 ohms. Between the sheath and the grounded conductor a potential of 33 volts undoubtedly would have been measured for this condition.

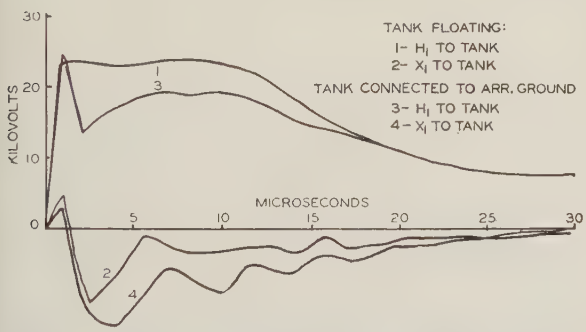


Fig. 25. Effect of connecting the transformer tank to the primary arrester ground

6-kv arrester; 10-ohm ground

Conclusions

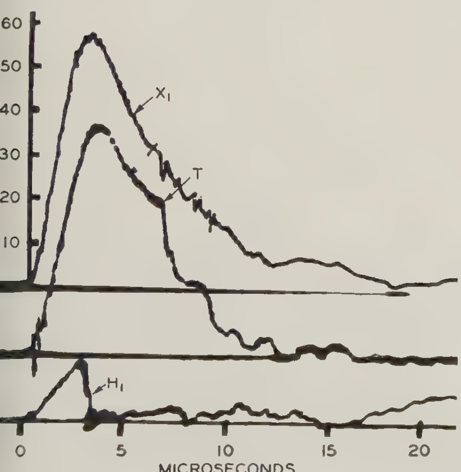
Conclusions reached from the results of these tests may be stated briefly as follows:

1. With the present method of connecting primary arresters, ground resistances play an all-important rôle in the protection afforded by the arresters; a ground resistance that may not be too high for one discharge may be totally inadequate for a higher current discharge. Since low ground resistance is expensive and frequently cannot be obtained, efficient protection requires that the variable effects of ground resistance be eliminated.

2. Impulses originating on the secondary network cause the transformer tank potential to rise above that of the primary and a primary failure may result although the surge entered from the secondary. Thus some failures charged to primary entrance may have been due to secondary entrance.

3. Grounding the transformer tank to the arrester ground is not particularly helpful as it reduces the primary-to-tank stress to the voltage allowed by the arrester, but increases the secondary stress by the *IR* drop in the ground.

4. Interconnection of primary arrester ground and secondary neutral will reduce the potential during lightning discharges to the voltage allowed by the arrester, whether impulses come from the secondary or primary circuits. With this interconnection transformers in reasonably good condition should not fail due to lightning surges, nor should fuses blow except in case of a severe direct stroke

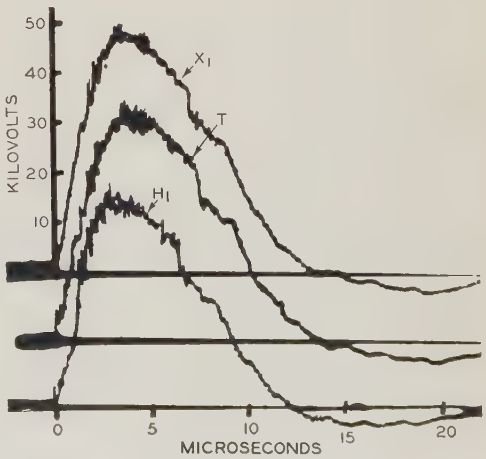


Surge voltages measured at the transformer with impulses applied to the secondary

Fig. 26. (Left) Primary arrester grounded in usual manner; resistance 19 ohms

Fig. 27. (Right) Primary arrester ground interconnected to secondary neutral but not grounded at the transformer pole

All oscillograms in each group have the same calibration



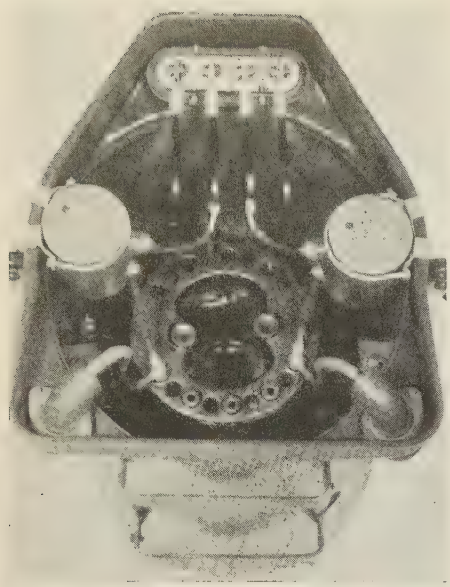


Fig. 28. Intershunt Thyrite lightning arresters mounted in a 25-kva distribution transformer for operation on a 2.4-kv isolated system

close to the transformer. Thus accidental connection between primary power supply and customer's premises should be practically eliminated.

5. Surge potentials at the transformer with the arrester ground interconnected to the secondary neutral is independent of the arrester ground resistance so that the transformer is protected whether the arrester ground resistance is high or low.

6. With the arrester ground interconnected to the secondary neutral, nothing is to be gained by connecting the transformer tank to the secondary neutral, since with the tank "floating," the potentials to tank are much less than the strength of insulation involved and the hazard to linemen is decreased.

7. Interconnection of primary arrester ground and secondary neutral allows impulse current to flow into the secondary network, the amount depending on the arrester ground at the transformer. The tests showed that even a 10-ohm ground did not prevent flashing some of the small gaps in the secondary house wiring; lightning discharges originating on the secondary do the same thing and interconnection increases the number of such discharges by the amount of exposure added. If a good arrester ground is used the severity of discharge in the secondary circuits will be reduced greatly. It is not believed that the increase in the number of discharges represents any increased hazard where the secondary neutral is connected to water pipe grounds, as in cities, even if the arrester is not grounded at the transformer. In rural distribution interconnection may represent some increase in hazard if several different grounds exist within consumer's premises so as to allow potential differences between different grounded objects and the secondary circuits.

8. From the standpoint of hazard due to power voltage, the present situation is that, in many instances of fuse blowing that may or may not have resulted from a transformer failure, power voltages of considerable magnitude appear between the secondary ground and separate grounds on the customer's premises; these voltages will persist until the fuse blows which may require many cycles, depending on the magnitude of the fault current. With good grounds on the secondary this time will be short and the voltage low; with poor grounds the time is longer and the voltage higher.

9. With the interconnection, it is believed that contacts between primary and secondary caused by lightning largely will be avoided thus materially reducing any hazard that may have existed before where the secondary ground resistance was high. In such cases the arrester probably should be connected to a ground at the point of interconnection to the secondary neutral.

10. The tests indicate that the record of arrester protection to distribution transformers, including fuse blowing, can be improved greatly by the interconnection, providing proper precautions are taken where the secondary neutral ground is not a water pipe ground; arrester grounds are not necessary where the secondary ground resistance is low as with waterpipe grounds.

Additional Notes on Interconnection

Since the paper upon which the foregoing article is based was written, tests have been completed by Duvoisin and Brownlee ("Impulse Characteristics of Fuse Links," *G. E. Rev.*, May 1932, p. 260) which indicate that valve type lightning arresters may be connected inside of fuses without having the arrester discharge current blow the fuses. These tests show that in order to blow a 1-amp low temperature General Electric fuse link a 1.5/40-microsec impulse must have a crest voltage of at least 123 kv; to blow a 5-amp fuse under the same conditions the crest potential of the traveling wave must be at least 625 kv. Considering the insulation of most distribution circuits it is doubtful if fuses of a capacity as large as 3 amperes would be blown by the discharge current through a valve type lightning arrester. The effect of the power follow current through such an arrester is quite negligible from the standpoint of blowing fuses during a lightning storm.

With interconnection of lightning arresters it is essential that some means be provided for clearing the circuit in the event that the arrester should fail. Connecting the arrester inside the fuses provides a satisfactory method for doing this, and not only isolates the arrester but also locates the trouble so that it may be cleared quickly. The impulse tests on fuses show that this protection can be secured satisfactorily without any sacrifice in service reliability if fuses of 3-amp rating or larger are used.

There has been some discussion concerning the use of interconnection on circuits operating nongrounded, on account of the potential that might appear between the consumer's wiring and a separate ground. Available information indicates that on a 4.6-kv system the potential across a ground resistance of 100 ohms connected between one line and ground would not exceed 100 volts, the system being 20 miles in extent. This assumes, of course, that the line conductors are free from grounds. It does not appear, therefore, that the failure of a lightning arrester would cause any serious voltages on the consumer's premises even with a ground resistance as high as 100 ohms.

Several of the larger operating companies now are trying interconnection on a scale sufficiently large that the results taken as a whole should be quite conclusive. Some of these companies who have felt doubtful of the interconnection in relation to the various codes have obtained the approval of the engineers of the Public Service Commissions of their particular states.

Intershunt Thyrite Lightning Arrester

If interconnection be employed it is convenient to mount the arrester inside the transformer tank so as to avoid external connections, thus decreasing the cost of installed protection and the amount of apparatus separately mounted on the pole. For this purpose a special Thyrite arrester has been developed consisting of an assembly of gaps and Thyrite within a sealed porcelain container and hung from the inside of the transformer tank. A transformer so protected is shown in Fig. 28. Such a location of the arrester insures the minimum length of leads and makes it possible for the arrester, which is connected between the

imary conductors and secondary neutral, to function most efficiently. The arrester is mounted in such way that the transformer tank is not a part of the rcuit. Thus the tank can be grounded or left isolated desired; if it be grounded it should be interconnected th the secondary neutral, so as to assure that the nk potential follows the secondary potential.

OMMENTS CONCERNING INTERCONNECTION

Since the A.I.E.E. 1932 winter convention in ew York, where the papers upon which these ticles are based were presented, there has been uch discussion concerning interconnection. This scussion may be more or less summarized in the atement that improvement in protection to the ansformer and reduction in blown fuses will relt, but where driven secondary grounds are in e, there may be some question concerning hazard. seems to the writers that the case for interconnecon versus the arrester ground connection can be ated in some such fashion as the following: With the arrester ground connection the protection of the transformer and the quality of the service depend upon the arrester, the ground resistance, and length of ground lead, while the safety of the consumer depends upon the quality of the secondary grounds. If the secondary ground resistance is high the consumer's safety also may depend upon the arrester and ground resistance as these may determine whether or not a primary-secondary contact is to be established. With interconnection the protection of the transformer depends upon the arrester only, while the safety of the consumer depends upon the quality of the secondary grounds.

Any arrangement which tends to make the secondary ground better is to be preferred, and of course this includes the interconnection of secondaries into a grid and also the interconnection of the primary neutral and the secondary neutral. Such connections establish a firm ground with many connections to ground, and should result in improved reliability both from the standpoint of lightning protection and hazard to the consumer.

Wiring Buildings for Good Illumination

Progress in securing good illumination in buildings has been impeded seriously by lack of sufficient wiring capacity. The situation is reviewed in this paper in the hope of stimulating engineering interest and thus promoting wider use of practises which will insure reasonable prospect of adequacy of lighting circuits throughout the life of a structure.

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CONTEMPORANEOUSLY with e development of lighting practise there has come o existence a group of illuminating or lighting rvice engineers associated with utility companies, ding lamp and equipment manufacturers, and some of the large users of light, who have interchanged data and experience with each other as well as with practising consultants.

A large measure of the effort of these engineers has been devoted to the repair and correction of lighting installations which for one reason or another have proved unsatisfactory in operation. They therefore have had an unusual opportunity of determining the border lines of satisfactory and unsatisfactory lighting. It is this experience, embodied in the criteria and rules for lighting practise, that has rendered the practise so reliable and secured its wide acceptance. While this experience has been dominantly with the smaller installations, in which for economic reasons paid consultants are not usually retained, it should be borne in mind that the more elaborate installations have at least as stringent requirements.

LIGHTING PRACTISE ADVANCING

The lighting practises developed have been expressed in papers and reports before various associations. Notable among these are the lighting codes of the Illuminating Engineering Society, the American Standards Association, and the International Commission on Illumination. The accepted illumination levels for the most common conditions of building lighting have been compiled in tabular form by leading illuminating engineers. Among other places these tables have been published in the Franklin "red seal" specification of the Society for Electrical Development, which also prescribes approximate rules for the lighting design of the simpler and more common classes of building interiors. This specification is probably the simplest, most condensed, and most comprehensive expression of present lighting practise; thus it furnishes a reasonable expression of the electric power requirements of that practise.

ed upon "Adequate Wiring of Buildings, an Essential for Good Illumina-" (No. 32-86) presented at the A.I.E.E. summer convention, Cleveland, o, June 20–24, 1932.

While electric lighting practise in the more common applications is comparatively definite, it is not static. Illumination levels, that is to say, the quantitative elements, have been rising steadily for many years and except for the retardation during periods of business depression, there is no indication that most fields have approached saturation. Moreover, there is an increasing demand for diffusion and reduction of glare which is generally secured at a sacrifice of light and therefore puts an additional requirement on the amount of electricity to be supplied.

While qualitatively these advances are generally recognized, it is exceedingly difficult to secure any quantitative measure for them, due to variations in application, locality, time, etc. Probably the best authoritative values for industrial lighting are published in the 1921 and 1930 issues of the "American Standard Code of Lighting for Factories, Mills, and Other Work Places," which have been published in pamphlet form and in the *Transactions* of the I.E.S., v. 16, 1921, p. 362 and v. 25, 1930, p. 607. The 2 issues give the values in different form and in some instances different classifications. However, a few samples have been selected and incorporated in Table I. It is probable that in most instances the advances are, if anything, greater than here indicated as the later values were presumably more widely exemplified in actual installations at the time of issue. It seems safe to say that, in general, the decade ending in 1930 witnessed approximately a doubling of light requirement for good practise in the principal classes of commercial, industrial, and office lighting.

Table I—Illumination Levels Good Practise

Class of Operation or Interior	Foot-Candles	
	1921	1930
Assembly —rough	2 to 5	8 to 5
—medium		12 to 8
—medium fine	5 to 10	
—extra fine	10 to 20	100 to 25
Chemical works—hand furnaces, etc	2 to 5	5 to 3
Cloth products—light goods	5 to 10	15 to 10
—dark goods	10 to 20	100 to 25
Elevators—freight and passenger	2 to 5	8 to 5
Forge shops	2 to 5	10 to 6
Foundries—charging floor	2 to 5	8 to 5
—fine molding and core making	5 to 10	15 to 10
Glove manufacturing—dark goods	10 to 20	100 to 25
Locker rooms	2 to 5	6 to 4
Machine shops—rough work	2 to 5	10 to 6
—medium work	5 to 10	15 to 10
—fine work	10 to 20	100 to 25
Offices—close work		15 to 10
—no close work		10 to 8
—private and general	5 to 10	
—drafting	10 to 20	25 to 15

Indications of Wiring Inadequacy

For a number of years illuminating engineers have been encountering installations in which suitable lighting could not be provided because of a lack of capacity in the wiring. Even where the safe carrying capacity of the wiring was not exceeded, excessive losses of electrical pressure in the wiring were frequently encountered so that the voltage delivered to lamps was considerably less than it should have been. Such losses were greatest at times when the demand was greatest, and resulted in serious reduction in light output and lamp efficiency. In a brief survey made in 1931 by an electric utility company in Ohio, it was found that the voltage drop in the interior wiring between meter and socket was frequently over 5 per cent and in some cases in excess of 10 per cent. Since operation of tungsten filament lamps at 10 per cent of rated voltage means a light output of only about 70 per cent of normal (see Fig. 1), it is easy to understand how unsatisfactory the illumination would be. This subject is discussed further in "Voltage and Incandescent Electric Lighting," G. S. Merrill, Preprint No. 137, International Illumination Congress, presented at Glasgow, September 1931. Oftentimes such conditions have been misinterpreted as being due to poor regulation of the utility's circuits or to defective lamps and have been a source of complaint from this standpoint. In extreme cases building owners have been compelled to incur the costly outlay of rewiring, but in a much larger number of cases, the expense has appeared prohibitive, and unsatisfactory lighting has been continued.

A review of the papers and reports presented before engineering associations shows careful treatment of practically every phase of electrical engineering except building wiring. It seems important that more attention be given this subject.

Future Lighting

In addition to the expected advance in illumination levels and degrees of light diffusion, there is a number of more or less new lighting applications going into use which bid fair to increase the electrical consumption. Among these may be mentioned light ornaments, that is, light sources to look at rather than for general illumination, ornamental portable lamps, indoor signal indicators, signs, etc. Some of these, while originating in the home, club, or hotel, are spreading to stores, offices, and other interiors.

For the past 5 years, the practise initiated in Europe of using so-called "built-in" lighting has been spreading rapidly in this country. Since such lighting formerly required special construction in the walls and ceilings, it was applicable only to new buildings or those in which extensive reconstruction was being undertaken. However, modified forms of luminaires similar to built-in equipment are beginning to appear, and these can be installed without difficulty in finished rooms and supplied from the usual electric outlets. This class of lighting is extending because of its artistic merit and in spite of a considerable reduction in efficiency measured in lumens per watt. It therefore represents an increase in electrical consumption which should receive proper consideration.

Another phase of lighting, which is still in the experimental stage but receiving enough attention to preclude ignoring it, is the so-called "dual purpose" health lighting. In addition to the visible light, these lamps supply the ultraviolet radiation which is depleted from daylight by window glass and city smoke and which is absent from the light of ordinary illuminants. Such equipment does not inherently require more electricity per unit of light than ordi-

ıry lighting, but the installations so far made dicate a tendency to employ higher wattage.

A compensating factor to the increased consumpon would be the use of more efficient light sources. ıe rapid increase in efficiency of incandescent mps from, say, 1912 to 1922 just about kept pace th the demand for more light, so that the electrical mand for a given area and purpose held fairly nstant throughout that period. Since then the lvance in efficiency has slowed down and although uminants of considerably higher efficiency have een produced in laboratories, it appears unsafe to epend upon any great increase in efficiency being idely applicable to today's installations within the xt 4 or 5 years.

Within the past 10 years large numbers of small otor and heating appliances have been connected to ghting circuits and apparently the next few years ill witness considerable increase in the load due to eir more extended use. They are valuable services ıd must be planned both for their own value and for e limits they otherwise would present to good ghting practise.

ΗΕ QUANTITATIVE ELEMENT OF WIRING

Interior wiring has received a great deal of attenon on the part of code writers, and has been the bject of numerous rules. By many in the elecical industry the National Electric Code has been ken as a standard of good engineering, overlooking e fact that the purpose of the code is fire prevention ıd other safety features. Being mandatory in aracter, the code cannot prescribe wiring on the ısis of economic engineering. Because of the mmon failure of those responsible for such wiring provide for later additions to the load it has been cessary for the code to anticipate these additions, ıt still on the basis of safety only. The code has een the subject of considerable controversy among e various interests involved. Since good engineerg would incorporate both the requirements for fety and economic operation, there is good reason believe that if good engineering were to prevail in is field these misunderstandings would disappear ıd the code assume its rightful position.

In the absence of generally accepted standards her than the wiring code, it has become a wideread practise for designers to establish arbitrary les and constants of their own making. In the ıaller installations the details of wiring are often termined by competing contractors eager to underd each other. Where consulting engineers are tained, they often are urged to justify their employent by minimizing investment and so find it diffilt to apply best engineering judgment. These rying circumstances all militate against the proper sponse of wiring practise to the needs of lighting.

In the report of a National Electric Light Associaon subcommittee on adequate wiring entitled, Lighting Service Manual," Part 3, p. 17, published the N.E.L.A., August 1928, the following conusions were drawn:

That to cut down the wiring specifications in order to reduce the tial investment was false economy as the greater losses would within a period of a year or 2 entirely offset the difference in investment.

2. That the investment in the wiring system did not increase in direct proportion to the increase in wiring capacity; doubling the wattage capacity increased the investment only about 1/3 while 50 per cent extra capacity meant an additional investment of only from 15 to 18 per cent.

It would appear therefore that in the interest of good engineering based upon economics what is needed is a reasonable standard, based upon good lighting practise, with an allowance for advances in the art and probable changes in the use of buildings. Such a standard would do much to overcome the insidious whittling which, in a considerable degree, has been responsible for the unsatisfactory condition.

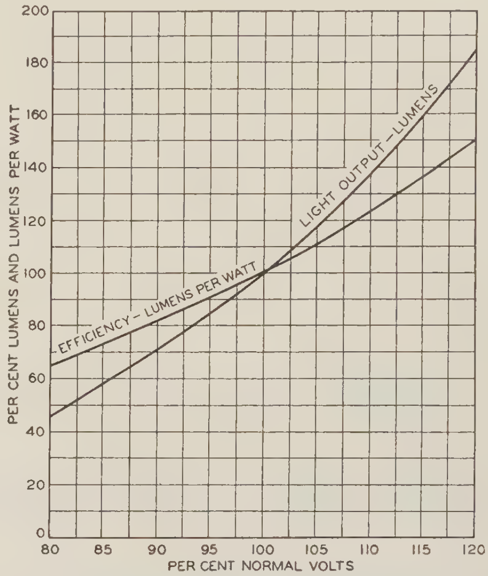

Fig. 1. Relation between illumination and voltage of tungsten filament lamps

ADEQUACY SPECIFICATION

A few illumination engineers about 1924 became conscious of building wiring as a limitation of good lighting. Previous to that time these engineers had concentrated upon the selection of lamps, luminaires, and locations. It became obviously important to give attention to wiring if the advance of illuminating engineering were not to be seriously impeded. The educational undertaking which resulted is described in "Adequate Wiring—A Problem of the Illuminating Engineer," G. H. Stickney, Preprint No. 125, International Illumination Congress, presented at Glasgow, September 1931.

Through the efforts of the N.E.L.A., preliminary paragraphs for an adequacy specification were agreed upon in the spring of 1929. Immediately some of the illuminating engineers, especially those associated with electric utility companies, began an informal application of the standards so embodied. The results were very gratifying. After a year's experience an extension of these paragraphs for commercial buildings was published by the N.E.L.A. in the pamphlet of March 30, 1930, entitled, "Minimum Specification for Adequate Wiring of Lighting Circuits in Commercial and Public Structures." A corresponding specification for industrial buildings

was issued under the same auspices on July 20, 1931, entitled, "Minimum Specification for Adequate Wiring of Lighting Circuits in Industrial Structures."

Several interested groups individually undertook the preparation of corresponding specifications for residence wiring, and in the fall of 1931 an industry committee was organized to coordinate the several undertakings into a single standard specification. This work is not yet completed, although the reports indicate that the end is in sight.

It is to be hoped that consulting engineers will familiarize themselves with these specifications and subject them to criticism, and that out of this there may come generally accepted standards of wiring practise. This would strengthen the weak link in the system of electric lighting, and encourage a normal development along the line of good engineering based upon economics. The public then could look with confidence to its advisers in the field of electric lighting, and be assured that good illumination, according to its needs, could be had in any building constructed under responsible auspices.

A Railway Motor Without Commutator

One of the latest uses for that versatile device, the grid controlled mercury arc rectifier, is to replace the commutator of an electric railway motor that will operate on either alternating or direct current. However, the rectifier eliminates not only the commutators in a locomotive equipped with these motors, but also all expensive control, switching, and reversing equipment. Experiments have shown so much promise that a 1,000-hp locomotive of this type now is being built in Switzerland.

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EXTENSIVE research work carried on for improving the mercury arc rectifier has led not only to improvements in its operation but also to entirely new applications of the device, and to new applications of the valve action on which its rectifying property is based. In recent years considerable experimental and development work has been carried out on rectifiers provided with control grids, utilizing the grids for interrupting short circuits and backfires, for d-c voltage control, for the conversion of direct current to alternating current, and for many other purposes. In this paper is described a new application of grid controlled mercury arc rectifiers in connection with a new single-phase commutatorless motor for a-c railway service.

Experiments carried out on a locomotive equipped with this type of motor have demonstrated the practicability of this scheme. Besides the elimination of commutators, practically all of the expensive switchgear and control apparatus is done away with, resulting in a simplification of the locomotive and a reduction in cost. In addition, it becomes possible to use a power supply of any available frequency, whereas at the present time frequencies of 25 cycles or less generally are required. While it is too early to predict where this development may lead, the marked advantages of a locomotive equipped with motors of this type, which are already apparent, may revolutionize the practise of railway electrification.

Operation of Energized Grids

Phenomena and characteristics of the mercury arc valve have been treated in great detail in various scientific journals. Its applications are many if equipped with a control grid which is introduced into the path of the arc. This grid is insulated from the anode and may be energized from an outside source of potential, such as a battery, auxiliary transformer, generator, or a combination of these sources. Non-energized grids or screens also are used to a large extent in mercury arc rectifiers for many purposes. (See "Mercury Arc Power Rectifiers," Marti and Winograd, McGraw-Hill Book Co., p. 42, 227, 232, 397.)

Some of the possibilities of energized grids are illustrated by the diagram of a 2-anode rectifier shown in Fig. 1. Let a sinusoidal a-c voltage be impressed on the primary side of the transformer, and let the grids be de-energized. The anodes will be positive during alternate half-cycles. During the half-cycle that anode 1 is positive, current will flow from anode to cathode through the load circuit, as indicated by the solid arrows. When anode 2 is positive, current will flow from anode to cathode through the load circuit, as shown by the dotted arrows. The current therefore flows through the load circuit in the same direction during both halves of the cycle. The same rectifying action will take place if a positive potential is applied to the grids during the intervals when the voltages of the corresponding anodes are positive. This could be accomplished by throwing switch S (Fig. 1) from one position to the other after each half-cycle, making the grid of anode 1 positive during the half-cycle when anode 1 is positive, etc., or by rotating commutator C at synchronous speed by means of motor M.

This is illustrated in Fig. 2. Section a shows the

Based upon "The Mercury Arc Rectifier Applied to A-C Railway Electrification" (No. 32-63) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932, and subsequently revised and brought more fully up to date.

ode voltages e_{10}, e_{20}. Shaded portions represent e d-c voltage wave (neglecting the arc drop). ction b represents the d-c wave for a resistance ıd. Sections c and d indicate the potentials ap-ed to the grids; shaded blocks represent the poten-ls if direct current is used, with a reversing or tating switch, as shown in Fig. 1, and the sine ıves represent the potentials if alternating current used.

In A of Fig. 2 is shown the condition when the grids e made positive at the instant when the corre-onding anodes become positive. Each anode then erates during half a cycle, and the average d-c volt-e is shown by line E_{dA}. In B of Fig. 2 is shown e condition obtained by shifting the brushes of the tating switch C, Fig. 1, through the angle α. The id potential then becomes positive α electrical de-ees after the anode potential, and the point at which e anodes start firing is delayed by the angle α, which duces the d-c voltage to the average value E_{dB}.

It can readily be seen that by shifting the brushes commutator C, that is, by changing the timing th respect to the voltage of the anodes, the rectifier n be stopped from passing current without inter-pting the primary supply or the voltage can be anged from the maximum value E_{dA}, to a value $_{B}$, or can be made as low as zero. The source of tential for energizing the grids, battery B, can be placed by an a-c source, which could be an auxiliary ansformer, a small generator, or the like. Several andard rectifiers equipped with such grid control ve been built at the West Allis works of the Allis-ıalmers Manufacturing Company and recently ere placed in service. They have proved entirely tisfactory.

Only a few hundred watts are required for con-olling power rectifiers. The grid control apparatus therefore quite inexpensive. This fact should be rn in mind when studying the commutatorless otor and locomotive described later in this article.

VERTED RECTIFIER

In the arrangement shown in Fig. 1, assume that e load is replaced by a d-c generator as shown. If positive voltage is applied to the grid of anode 1, rrent will begin to flow through the left-hand por-ɔn of the secondary winding of the transformer, ducing a voltage in the primary winding. After a rtain time interval let the grid of anode 2 become sitive, and current will start to flow through the ght-hand portion of the secondary winding of the ansformer. If at the same time the current in ode 1 can be reduced to zero by some means or her, then the rectifier and associated equipment ould be nothing else than a converter feeding power ɔm the d-c into the a-c network. Although the w of current from generator G through the anodes n be controlled by energized grids only as to the ne of starting, other methods have been developed r reducing the anode current to zero in the proper quence to obtain inverted operation of a conven-ɔnal rectifier so as to convert direct current into ernating current. (See Kern, *Bulletin Schweizer-cher Elektrotechnischer Verein*, 1931, p. 538.)

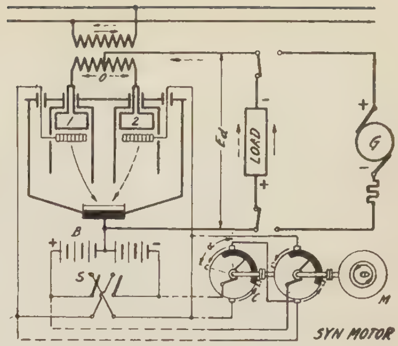


Fig. 1. Controlled-grid valve that can be used either as a rectifier or a d-c to a-c converter

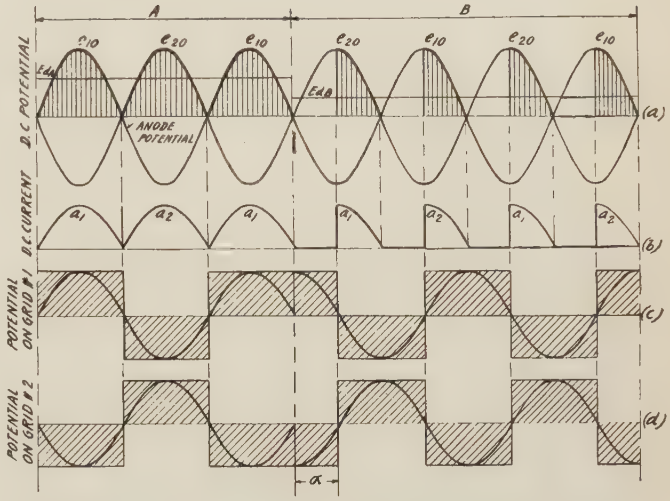


Fig. 2. Curves illustrating voltage regulation and control by means of energized grids

This feature opens up great possibilities for the now fully developed mercury arc rectifier, and many new applications for the mercury arc valve.

Commutatorless Single-Phase Railway Motor

For some time portable substations equipped with mercury arc rectifiers have been built abroad and in this country. As far back as 1914 a 250-hp motor car, equipped with a mercury arc rectifier, was in service in this country, on the New York, New Haven, and Hartford Railroad. As some experience therefore already is at hand, it will not be a novelty to put a rectifier on a locomotive, except in its use as a static commutator for the traction motors.

Present standard series a-c or d-c traction motors are limited to comparatively low voltages by their commutators, and therefore the controls for these motors are expensive. The commutator also makes the construction of the motor expensive, and involves the troublesome difficulties inherent in mechanical commutation. It has been found possible to replace the commutator by a series of electric valves, *viz.*, a mercury arc rectifier, by the use of which the dis-advantages mentioned are obviated. This scheme can be applied to single-phase or d-c motors so that relatively high voltages can be used, thus reducing the size and weight of the copper used in the connec-tions. At the same time, a very desirable speed-tractive effort characteristic can be obtained. Fur-thermore, all expensive control, switching, and re-

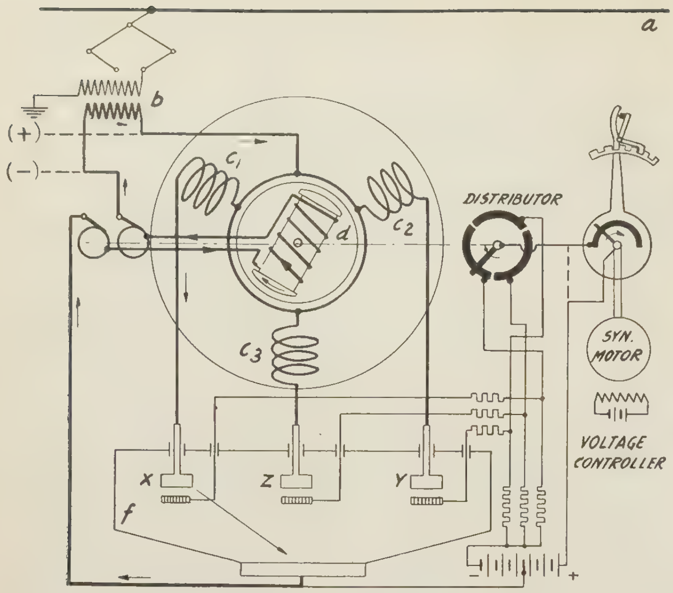


Fig. 3. Elementary commutatorless motor

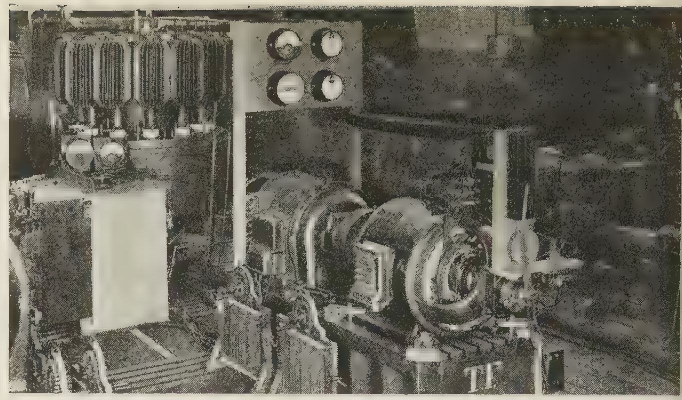


Fig. 4. Commutatorless rectifier motor on test

versing equipment is dispensed with, while a rectifier and a very simple and cheap grid control is added.

Referring to Fig. 3, it may be seen that the commutatorless motor consists of an armature winding *c*, a field winding *d*, and a distributor mounted on the shaft of the motor. An integral part of the motor is the grid controlled rectifier *f*. The complete outfit includes, in addition, a single phase transformer *b*, a synchronous rotary switch, and the control battery; *a* is the trolley wire. The armature windings of the motor are in the stator and the field winding is on the rotor for the same reason that this practise generally is followed in the design of synchronous motors. By doing so only 2 slip rings are necessary for the field windings, whereas if the armature were wound on the rotor 4 slip rings would be required in this particular case, and even more for practical applications.

In order to understand the function and operation of the distributor, assume for a moment that the armature is on the rotor and that the field is in the stator. The distributor then corresponds exactly to the conventional commutator of a d-c machine, that is, it distributes or shifts the current from one armature coil to the next at the proper moment, just as the conventional commutator does in a conventional motor. However, instead of carrying the total armature current, or, as in a series motor, the total motor current, the distributor has to handle only a very small current—a fraction of an ampere; it controls the rectifier which carries the full motor current and performs the actual commutation. Now, considering this motor again as it actually would be built with the armature stationary and the field fed by slip rings, it is evident that the distributor still performs the functions of a commutator. In other words, the distributor controls the flow of current through the various coils of the armature winding as a function of the position of the rotor just as a conventional commutator would do the same thing, and has no effect on the speed of the motor.

In operation, let it be assumed, first, that the rectifier equipment is in the position shown, and that one grid (of anode *x*) is energized positively through the distributor. This grid accordingly permits current to flow through the anode which it controls. All other grids will be energized negatively thus preventing current from flowing through their anodes. As the primary winding of transformer *b* is energized from the line, a half-wave current will flow through the winding of rotor *d* and through c_1, as indicated by the arrows. As can readily be seen, the field produced in the windings c_1 and *d* will produce a torque which causes the field *d* to rotate. At the proper time, the shaft of the motor *e* brings the brushes of the distributor to such a position that the grids of anodes *z* and *x* now are energized negatively, while the grid of anode *y* is energized positively, permitting current to flow from anode *y* into winding *d*, and through c_2. This process is repeated in sequence for all windings of the stator, thereby producing a continuously rotating motion of the rotor.

Continuous Speed Control

The speed of the motor is determined by the same factors which determine the speed of any series motor, whether d-c or a-c, namely, the load on the motor and the voltage across it. In the case of a d-c series motor, the voltage across it would be determined by the series resistance, which can be cut in or out in steps; a-c series motors are controlled similarly by means of resistances or taps on an auto-transformer. Both of these schemes have their obvious disadvantages as follows:

1. The speed is regulated in steps.
2. A considerable loss in energy generally is involved.
3. The control apparatus is expensive, becoming more expensive as the number of steps is increased.

In the commutatorless motor, continuous speed regulation can be obtained without loss of energy and with inexpensive equipment. In Fig. 3 may be seen a rotary switch called the voltage controller, driven by a small synchronous motor from the main supply. This voltage controller prevents the formation of an arc in the rectifier before a certain point in the cycle of the voltage wave. This point can be determined by shifting the position of the stationary contact of the voltage controller so that the anode can be made to pick up at the very beginning of the

itive half of the voltage wave, or can be entirely vented from picking up. Any intermediate posi-n, of course, can be obtained. Referring to the planation of voltage control of rectifiers by means energized grids, it may be seen that actually the erage voltage across the motor is being controlled. this mean speed regulation of the motor is ob-ned, and it is evident that this regulation is con-uous from zero up to the speed for which the motor lesigned. It is evident also that the same voltage troller can be used for starting the motor.

The motor illustrated in Fig. 3 utilizes only one f of the applied voltage wave, and hence would not considered in a practical case. A connection refore is used whereby the full wave is utilized. oreover, the armature windings are arranged so t although each conductor carries only a pulsating directional current, each pole is energized con-uously for 180 electrical rotor degrees in one direc-n, and in the other direction for the next 180 de-es. Magnetic conditions in the motor therefore the same as in a d-c machine, and there is no dency for the motor to "lock in" at synchronous sub-synchronous speeds.

This motor has a series characteristic which is irable for traction purposes. A resistance can be nected across the stator winding, so that the tor can be given the characteristics of a repulsion tor. It is also possible to connect only the rotor the source of power, in which case the stator cir-ts are closed only through the rectifier, and the stator currents are obtained by induction through the rotor. The stator, being then no longer connected to the circuit, can be wound for whatever voltage is found most desirable. (See Kern, *Elektrische Bahnen*, November 1931.)

Motor Can Operate From Direct Current

Considering the magnetic conditions in the commutatorless motor, it can be shown that a motor can be designed to operate from a d-c source. The counter emf is used to enable the rectifier to commutate the current from one armature winding to the next. During the starting period, before sufficient back emf is available, a small auxiliary machine supplies the commutating voltage. It is possible to design a motor which will operate either on 25 or 60 cycles, or on direct current. A locomotive therefore can be designed which will operate on, say, 11,000-volt, 25-cycle main lines, and also on 3,000-volt d-c systems in metropolitan areas.

Summarizing, we have a motor which can be used either on 25 or 60-cycle systems or on high voltage direct current. Starting and controlling the motor is effected by controlling the average d-c voltage across the motor without loss of energy. The motor is reversed merely by shifting the stationary contacts of the distributor 180 electrical degrees. Regenerative braking is obtained by shifting the distributor and voltage regulator. Thus all control operations, starting, running, reversing, and braking of the loco-

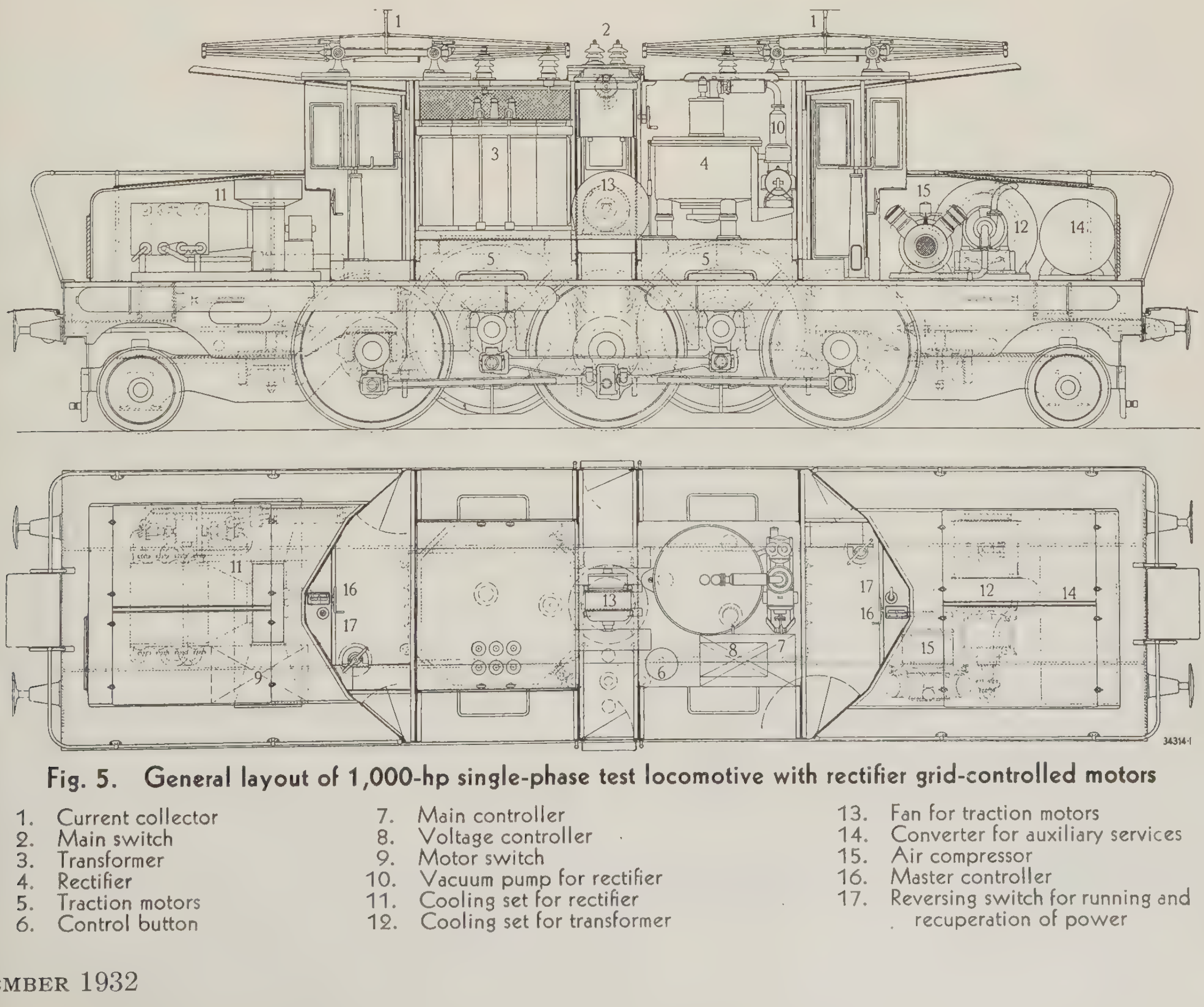


Fig. 5. General layout of 1,000-hp single-phase test locomotive with rectifier grid-controlled motors

1. Current collector
2. Main switch
3. Transformer
4. Rectifier
5. Traction motors
6. Control button
7. Main controller
8. Voltage controller
9. Motor switch
10. Vacuum pump for rectifier
11. Cooling set for rectifier
12. Cooling set for transformer
13. Fan for traction motors
14. Converter for auxiliary services
15. Air compressor
16. Master controller
17. Reversing switch for running and recuperation of power

motive, are accomplished by shifting the stationary contacts of the voltage controller and of the distributor, both of which are small pieces of apparatus.

In Fig. 4 is shown the first experimental model of such a commutatorless motor directly coupled to a generator as load, and with a commercial rectifier of large capacity. The control hand-wheel is visible on the right.

In conclusion it is of interest to note that Brown, Boveri & Company, Ltd., of Baden, Switzerland, at present is building a single-phase locomotive to be operated directly with single-phase power of 50 cycles at 15,000 volts. The locomotive is of standard gage and is equipped with two motors of 500 hp, one-hou rating, for a maximum speed of 90 km per hr (5 mph). (See Fig. 5.) It is designed for regenerativ braking. This locomotive has no commutators, ta switches, starting resistances, or reversing switches in the motor circuit. All such equipment is replace by a high-voltage mercury arc rectifier with contro grids. Tests with this locomotive will be highly significant in view of the possible utilization of alternating currents of commercial frequencies for th electrification of main line railroads.

The Rock Island Hydroelectric Development

First electric power development on the famous Columbia River, the initial 60,000-kw Rock Island plant also is the first major low head installation on the Pacific Coast, a territory long famous for its high head plants, and has the largest installed capacity in adjustable-vane propeller-type wheels of any plant in the United States. Some of the project's many departures from conventional design are revealed in the accompanying text and illustrations.

By
A. P. NEWBERRY

GEORGE C. SEARS
MEMBER A.I.E.E.

Both of
Puget Sound Power &
Light Co., Seattle, Wash.

THE ROCK ISLAND hydroelectric plant is being built as a unit of the Puget Sound Power & Light Company's system which supplies electric service to a large territory lying west of the Cascade Mountains in the State of Washington. The development is interesting in that it is the only large low head plant in a section where high heads are the rule and therefore presents certain features of design that generally are not found on the Pacific Coast. Further, it is the first step in the development of the enormous power resources of th Columbia River, one of the most famous streams i North America.

The plant is located east of the Cascades on th Columbia River in central Washington about 1 miles downstream from Wenatchee. From th plant 2 130-mile 110-kv transmission lines cross th mountains through widely separated passes to connect at different points with the company's syster around Puget Sound where the major portion of th station's output will be used. The main powe supply of the system at present is from hydro plant on the west side of the mountains supplemente by a relatively new 80,000-kw steam-electric generating station in Seattle. While there is some diversit in the various rivers due to the different altitudes o their watersheds, they all have the characteristic typical of glacially fed streams, high water in th spring and summer and low flow in the fall an winter. Even with appreciable amounts of storag available to fill in the low periods, there is a natura reduction in hydro capacity at those times requirin the operation of steam stations to make up th deficiency. Conditions at Rock Island are suc that, with maximum capacity and output availabl at low water and the reduction in both occurring a high water, this plant fits in admirably with th other stations.

Water Supply

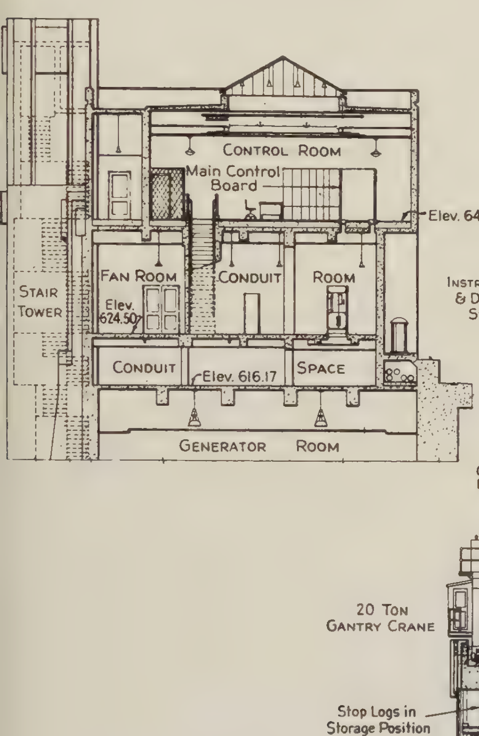
The Columbia River at the dam is fed by a drain age area of some 90,000 square miles extending fro the Cascade Mountains on the west to the Rocki on the east, and including parts of Washingto Idaho, Montana, and British Columbia. Precipita tion in the upper Columbia watershed varies fro less than 15 in. in eastern Washington to near

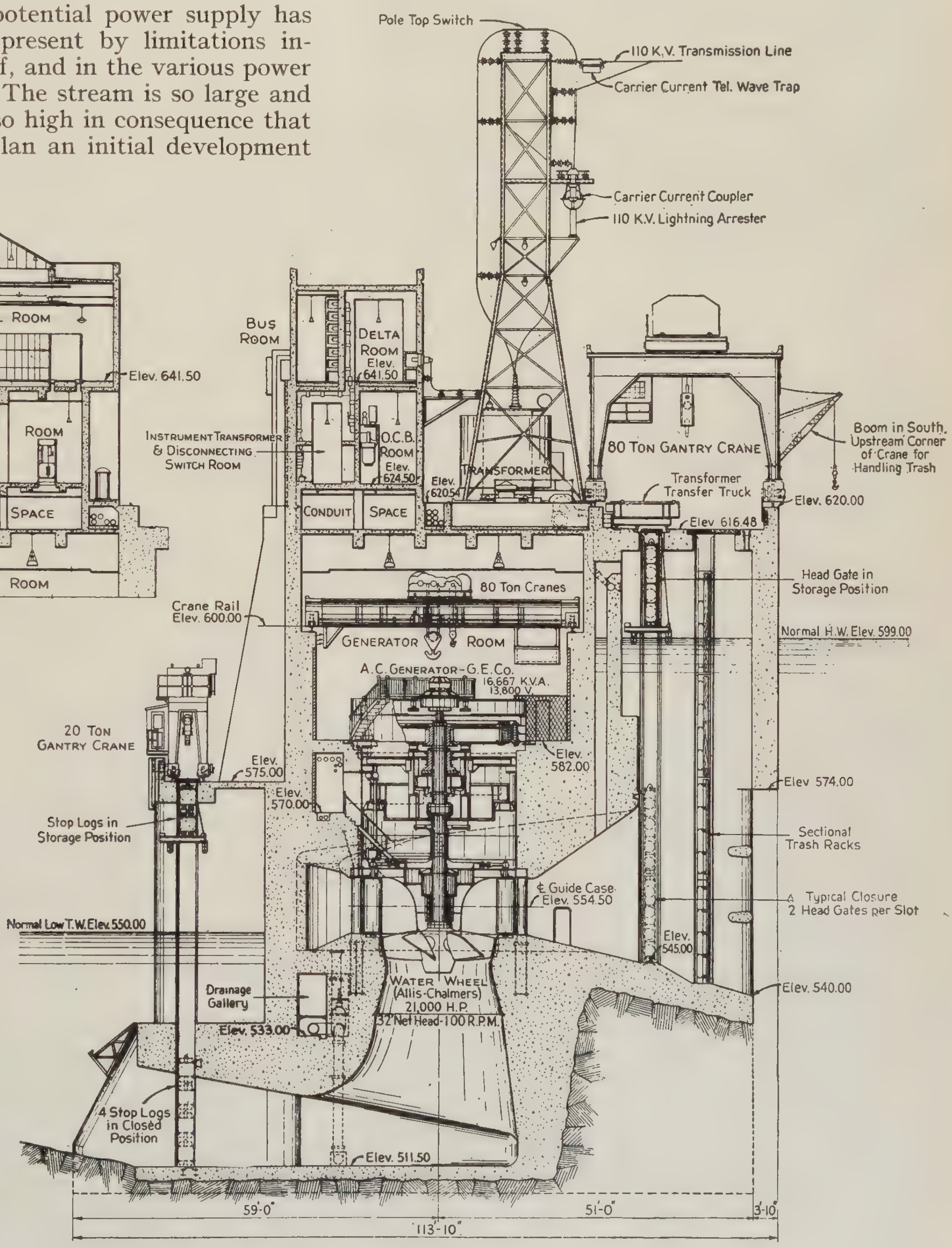
Full text of a paper presented informally at the A.I.E.E. Pacific Coast convention, Vancouver, B. C., Aug. 30–Sept. 2, 1932, as enlarged and rewritten especially for ELECTRICAL ENGINEERING through the cooperation of the Stone & Webster Engineering Corporation, Boston, Mass. *Not published in pamphlet form.*

in. in British Columbia. This upper portion of drainage area includes many lakes and glaciers, l mountain ranges almost perpetually covered with w. Nearly all the precipitation on the entire tershed comes in the winter in the form of snow ich lies on the ground until spring. Hence from tober 1 to April 1 the supply is almost entirely und water, maintaining a remarkably uniform v averaging about 40,000 cfs and rarely exceeding ,000 cfs. As the snow melts, beginning usually out April 1 on the lower lands and gradually ex-ding to the higher levels, there is a discharge adily increasing to a maximum about the middle June. This maximum varies widely from year year depending upon the amount of snow in stor- and the rate of run-off. The maximum flood on ord since 1858 was 740,000 cfs in 1894; the rest recorded flow about 21,000 cfs.

Development of this potential power supply has n delayed until the present by limitations in-ent in the stream itself, and in the various power s available along it. The stream is so large and cost of construction so high in consequence that has been difficult to plan an initial development that would show good economy. The opinion generally held has been that any Columbia River water power development would require a market larger than could be furnished by any one of the adjacent power systems. Further, the nature of the river channel below the dam is such that, with increasing flow, the water level below the dam rises much faster than the level above until, with extreme floods, the differential may be less than 20 ft. However, this reduction in head and consequently in plant capacity, comes at a time when all other plants on the system are at their best in productive capacity, and therefore is not a handicap to economical operation.

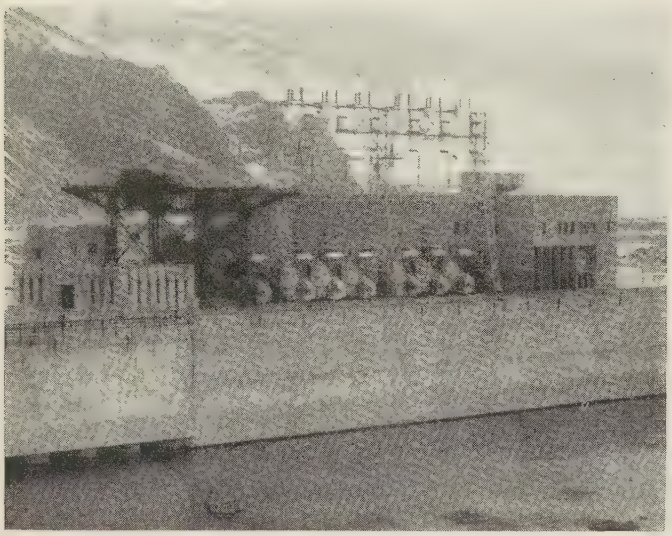
The Columbia basin in eastern Washington is underlaid by basaltic formation made up of separate layers or flows of lava superimposed one above the other. In general, these layers are horizontal and





tion through the Rock nd power house at one of main units, revealing y of the features of de- including the elimina- of penstock and the cur- wall which keeps ice and n from the intake chamber. tion through the control m bay also is shown above he left

in much the same position as when first deposited. One of these sheets of basalt forms the rapids at Rock Island, and is the foundation on which the dam is built. (See front cover.) Chief among the advantages that led to the selection of this location are (1) good foundation and favorable topography; (2) proximity to a transmission line already constructed; (3) site on the main line of the Great Northern Railway; (4) amount and character of available power is such that it can be utilized economically by the power company.



Upstream view of the Rock Island power house showing the outdoor transformers with associated forced air cooling equipment

The Dam

The dam is a concrete structure built to develop an effective head of 32 ft at its initial height. Ample water is available for full capacity of the present installation at that head, but with the addition of more units the dam will be raised to give an effective head of 48 ft. Spillway capacity sufficient to pass extreme floods is provided by 37 gates each 30 ft wide, 18 of which have their sills at el 559.0, and the remainder at el 581.5. In the initial development a free crest at el 581.5 will be maintained by using gates to that height in the deep slots, except in very high water when some of these gates will be opened to hold the pond level within the project boundary. With the installation of more units, piers will be raised and gates placed to el 599.0 to provide the 48-ft head.

Requirements laid down by the Federal Power Commission in its construction license covering the project called for a design that would provide immediately for the free passage of salmon over the dam, and provide ultimately for the possible development of the upper Columbia River as a navigable stream. At present there is extensive navigation in the lower regions of the river, particularly from Portland to the Pacific, but the degree to which the river is navigable diminishes upstream because of the increasing number of rapids, and reefs which offer serious obstruction to free navigation. Contemplated future possible improvements of the upper portion of the river are based upon plans for securing slack water navigation by means of a series of locks and dams. When completed to its ultimate height the Rock Island dam will provide a navigable pool about 14 miles long at low water. To permit the possible use of this pool for navigation the structure has been so designed that a lock could be constructed on the river bank opposite the power house in place of a portion of the present abutment.

Perhaps one of the most interesting features of the development is the pair of fish ladders provided for the passage of salmon which are going upstream in varying quantities at practically all times. Because of the importance of maintaining the fish run, careful study was given the problem of getting them over the dam until final plans were worked out in conjunction with state and federal authorities and a ladder was constructed in each abutment. Each of these ladders is some 500 ft long and provides 45 steps each 1 ft high, 10 ft long, and 20 ft wide. Sufficient water is used to assure a depth of more than a foot over the weirs, thereby permitting the fish to swim readily from one pool to the next rather than forcing them to jump. It is almost impossible to see the fish progress through the ladder, but the presence of a normal number of salmon at points up the river indicates satisfactory operation.

Power House

The power house, also of concrete, is built into the dam adjacent to the north abutment and, while the present building will accommodate only the initial 4 units, the foundations are in for the ultimate 12 turbines which will require a building 880 ft long. That the power house design embraces several unusual features may be seen from the accompanying illustrations. Perhaps one of the most interesting of these arises from the necessity of providing for the possibility of extremely high tailwater by eliminating from the building all windows and other exterior openings below the main deck, which is about on a level with the roof of the generator room. In the office bay and the control room, located above the deck, the design provides for the normal proportion of windows, but throughout the plant excellent working conditions under close control are provided by artificial illumination and forced ventilation.

Air conditioning equipment is installed in connection with the ventilating system and even with the extremes of temperature of the eastern Washington climate satisfactory temperature control is obtained. Winter heat is provided by drawing warm air from the generators and forcing it to all parts of the building with blowers, together with sufficient air drawn in from the outside to keep conditions at the proper point. In summer the generators are closed and their heat absorbed by air coolers, and fresh air after being properly conditioned is circulated throughout the entire building. In addition to the ventilating

ıd lighting system there is a complete system of tile rains laid in the substructure walls to intercept epage through them and convey it to a sump hence it is removed by pumps.

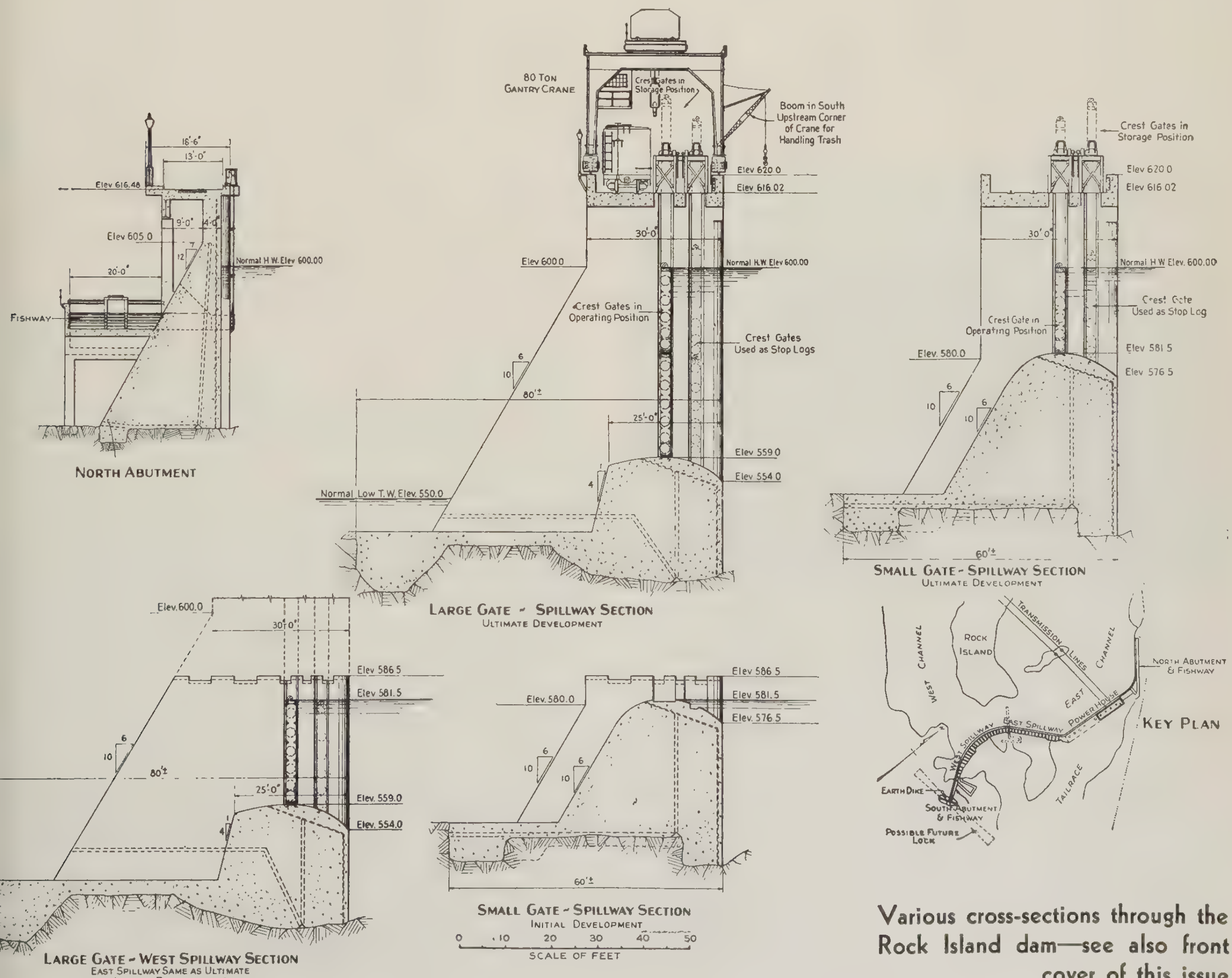
'ATERWHEELS

Waterwheel equipment as selected for the Rock land plant has been designed to enable the proıction of as much power as possible under a reıced head, and at the same time to enable operation ıder normal conditions without an excessive deease in operating efficiency. These wheels will evelop 21,000 hp, equivalent to normal generator ıpacity, under a head of 32 ft, although they are esigned to operate efficiently under a head of 48 ft. ach wheel will produce about 9,500 hp under a)-ft head.

The initial installation consists of 4 vertical shaft ıits rated 21,000 hp at 32-ft head. These wheels e of the propeller type, with adjustable vanes lected because of the low and varying head condions, and they constitute one of the largest installaons of this type in the United States. The cast eel runners are 18.75 ft in diameter, are designed operate at 100 rpm under heads varying from) to 48 ft, and carry 6 vanes each. To maintain ıpacity as high as possible at low head, and efficiency as high as possible at high head, the vanes are adjustable by means of a geared operating shaft which extends up through the hollow turbine shaft to the coupling between the turbine and the generator. Adjustments can be made only with the machine at rest, when changes may be made in from 5 to 10 min with the aid of a portable air motor. To protect the gear mechanism from water the runner hub and the gearbox are filled with a cup grease kept under high pressure.

The reinforced concrete scroll case for each wheel is directly connected to an intake opening in the face of the dam, and each opening is divided into 3 headgate sections each 27 ft 11 in. high by 15 ft 4 in. wide. Closure of the intakes may be secured by the insertion in each section of 2 steel gates fitted with rubber seals. Protection from drift is provided by trash racks made up of steel bars spaced on 12-in. centers and so arranged that electric heating may be used if required to combat ice. In addition to this a concrete curtain wall is placed upstream from the racks extending some 8 ft below minimum headwater level, serving effectively to fend off floating logs and ice.

The flow of water through the wheels is regulated by welded steel wicket gates 9 ft high and controlled by oil pressure governors whose flyballs are gear driven from the turbine shaft. As is usual with



Various cross-sections through the Rock Island dam—see also front cover of this issue

this type of turbine, the wheels are set below normal tailwater and for access to a wheel it is necessary that the draft tube be closed as well as the headgates. Steel stoplogs are provided for insertion at the discharge from the draft tube and, with headgates and stoplogs in place, 2 vertical pumps each of 5,000-gpm capacity are used for unwatering the scroll case and draft tube. The draft tubes are of modified elbow design.

Electrical Equipment

The generators are of the umbrella type each with combined guide and thrust bearing below the rotor; each is rated 16,667 kva, 13.7 kv, 0.90 power factor, 60 cycles. Each stator has an over-all diameter of 28 ft 8 in. A closed recirculating type of ventilating system equipped with air coolers of the surface type is provided for each main generator. Welded steel construction is used throughout and the rotor is of especially rugged construction to withstand the runaway speed of 230 per cent of normal. Excitation is provided by 250-volt main and pilot exciters mounted on the top of each generator shaft, and voltage control is secured by automatic rheostatic voltage regulators on each unit. The neutral of each generator is connected through an oil circuit breaker to a bus which is grounded through a resistor.

Each group of 2 generators is connected through their respective oil circuit breakers to a 13.8-kv bus from which power is fed through a transformer bank to a 110-kv transmission line. Each bank of

The Rock Island control board uses steel panels both front and rear. Indicating meters and control switches are mounted on the front panels; recording meters and relays on the rear panels

3 single-phase transformers has a rating of 30,000 kva with self-cooled operation, and 45,000 kva with forced air cooling. High-speed solenoid-operated oil circuit breakers are installed between the generators and the bus and between the bus and the transformer. A 13.8-kv transfer bus provides a means of interconnecting the stub buses, should operating conditions require it. All bus work including the transformer deltas are of copper bars and are housed in indoor concrete cells. Each of the 2 main transformer banks is connected to an outgoing 110-kv line through a motor-operated disconnecting switch which is controlled from the switchboard and interlocked with the oil circuit breaker on the low voltage side to prevent the disconnecting switch from being used to interrupt power. All generators, buses, and transformers have individual differential protection, but no overload. Directional ground, and impedance relays open the 13.8-kv circuit breakers on the transformers in case of trouble on the transmission lines.

The control board is shown in one of the accompanying illustrations. Individual panels are assigned to each generator and to each transformer; 2 panels are used for graphic frequency meters, totalizing meters, voltmeters, and special instruments. Control board wiring is carried on brackets along the edge of each panel and brought down to terminal blocks in a special box in the room directly below the board. Except where walls and mass concrete prevent, wiring is in exposed conduit, and a special room is provided below the electric bay for conduit racks.

Because of the importance of auxiliary equipment in a station of this size, two sources of station power are provided. A 1,760-kva 460-volt vertical generator driven by a propeller waterwheel rated at 2,100 hp at 32-ft head is the primary supply; a 1,760-kva 3-phase transformer provides a secondary supply from the 13.8-kv transfer bus. The 460-volt bus is sectionalized with automatic air circuit breakers to isolate any section that might be in trouble. All important auxiliaries are served by duplicate feeders energized from different sections and equipped with automatic throw-over switches.

General Information

For the handling of the heavy generating equipment, 2 80-ton cranes are installed in the generator room, each having also a 15-ton auxiliary hoist. Special lifting devices are used on the larger parts to reduce the headroom required for their handling. An 80-ton gantry crane with automatic blocks is used for operation of the crest gates and the head gates. Another 20-ton gantry is provided on the tailrace deck for setting the draft tube stoplogs. A 75-ton transfer crane which traverses the building is used for handling material to and from the tailrace deck, and also for the transfer of materials and equipment from standard cars on the deck through a hatchway in the ceiling of the generator room to the floor below.

To give an idea of the size of the project and the quantities involved, the following few figures are quoted:

Reservoir area	3,000 acres
Total estimated excavation	335,000 cu yd
Total estimated concrete	235,000 cu yd
Total ultimate length of power house	886 ft
Total length of dam and abutments	3,500 ft

The initial development when completed will make available in an average water-year about 480,000,000 kwhr, whereas the ultimate installation is expected to

oduce about 1,220,000,000 kwhr annually. This tter figure is equivalent to running the contem-ated 150,000-kw capacity continuously at full ad for 93 per cent of the time.

In addition to the more usual exploration and test orings on the dam site, and observations and easurements of stream flow, a laboratory model of e entire dam site was made in order to check the w condition and the discharge capacities of the oposed structures. This model represented a 000-ft stretch of river 3,000 ft wide and was made a scale of 100 to 1. Upon this were built models of the proposed dam and power house, and water in the proper amount was allowed to flow through these structures to give an index of the correctness of design. Cofferdams also were included in the model experiment in order to determine in advance the required height of the necessary cofferdam for both channels of the river under the various flow conditions that were to be expected during the construction period. Observed water levels at the dam site resulting from construction of the actual cofferdam agreed closely with the advance expectations based upon the laboratory model experiment.

Abstracts

Of Papers to Be Presented at the Baltimore District Meeting

NTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for esentation at the A.I.E.E. Baltimore District eeting (Oct. 10–13, 1932) are published herewith. response to popular demand and within its space nitations ELECTRICAL ENGINEERING subsequently ay publish certain of these papers, or technical ticles based upon them.

Members vitally interested and wishing to obtain a mphlet copy of any paper available in that form ay do so by writing to the A.I.E.E. Order Dept., 33 est 39th Street, New York, N. Y., stating title, thor, and publication number of each paper desired.

15-Kv Submarine Cable Crossing of the Columbia River

By
E. F. Pearson[1]
G. B. Shanklin[2]
W. R. Bullard[3]
S. B. Clark[1]

THE FIRST submarine installation of oil filled cables in s country has been made. It is a 115-kv cable crossing the lumbia River just north of the city limits of Portland, Ore. The ection of a nominal transmission voltage of 110 kv was determined an economic analysis based on various schemes of delivering rgy to load centers in the Portland area. Conditions were found orable for laying the cable directly on the bed of the river without digging of a trench. Three cables were laid 4 ft apart, and the re ends above extreme low water were trenched in and covered h 4 ft of sand. Oil filled cable was found to possess many vantages for this particular service and therefore was specified tead of cable with solid insulation.

The present paper, in addition to giving the reasons underlying principal decisions regarding the cable, includes a section on the ign and manufacture of the cable and accessories, a description the design of features incorporated in the field installation, and procedure followed in making the actual installation. Many isual construction problems were encountered but by careful nning were solved successfully and operation of the cable under normal conditions since June 19, 1932, has been very satisfactory. Cable temperatures and oil level fluctuations have followed very closely the values calculated for varying load conditions. (**A.I.E.E. paper No. 32-125**)

1. Northwestern Electric Company, Portland, Ore.
2. General Electric Company, Schenectady, N. Y.
3. Electric Bond and Share Company, New York, N. Y.

Thermal Transients and Oil Demands in Cables

By
K. W. Miller[4]
F. O. Wollaston[5]

SINCE underground power cables almost always operate under variable loading, it is desirable to establish their allowable carrying capacities on the basis of variable loading rather than upon the basis of some equivalent steady state loading, as is the present practise. For this purpose it is most useful to know what temperature variations will occur at any point in the cable at any time due to an abrupt change from one constant load to another. Then any load curve can be handled with sufficient accuracy by breaking it up into a series of rectangular steps, and adding with proper time intervals the successive thermal transients.

The fundamental equations were developed several years ago, but the numerical solution was too complicated and laborious to be of general practical value. A simplified method is presented in this paper, which employs calculating charts and other devices permitting exact and complete solutions to be obtained and verified in one day, in contrast to approximately one week as required by the former methods. The theory has been verified by measurements on actual cables of the ordinary and oil filled type. In addition to solutions for temperature transients due to abrupt load changes, precise simplified solutions for the following related phenomena are given:

1. Oil demands due to abrupt load changes in oil filled cables.
2. Temperature transients and oil demands due to load variations of any kind, whether abrupt or otherwise.

Although the methods described in this paper were developed for problems of single-conductor cables, they can be applied also directly to 3-conductor cables, using a per phase basis. For oil filled 3-conductor shielded cable with round conductors, the accuracy will be excellent. If the conductors are sector shaped, good accuracy may be obtained by using the equivalent round conductors. For ordinary

4. Utilities Research Commission, Chicago, Ill.
5. Commonwealth Edison Company, Chicago, Ill.

3-conductor cable with solid fillers and no shielding, the accuracy will be only fair.

The duct temperature transient is of importance in problems of variable loading, but has not been adequately investigated; further work should be done along this line. Some of the constants needed for use in thermal and oil-flow problems of cable insulation are relatively new; many of the values now in use for these constants are based upon only a few scattered observations and further laboratory and field data should be obtained. **(A.I.E.E. paper No. 32-127)**

Traveling Wave Voltages in Cables

By
H. G. Brinton[6]
F. H. Buller[2]
W. J. Rudge, Jr.[6]

WHEN a traveling wave on an overhead line reaches a cable, a wave of reduced voltage passes into the cable. This reduction is due to the fact that the surge impedance of a cable is less than that of an overhead line. In a traveling wave the electrostatic energy is equal to the electromagnetic energy, and the constants of a cable are such that the voltage of a traveling wave has a lower ratio to the current than in the case of a wave on an overhead line. After the wave enters the cable there are voltage and current reflections back and forth from each terminal. If the length of the original wave is great enough, there will be several superimposed waves at each point in the cable. The sum of these several waves will be dependent upon the shape of the original wave as well as upon the reflections.

The reflection at the cable terminal depends upon the surge impedances of the cable and of the connected line or apparatus. In this paper, calculated values of voltage are given for a range of cable surge impedance from 20 to 150 ohms, and line impedances of 300 and 500 ohms. The calculations include the case of similar lines connected to each end of the cable, and the case of a line connected to one end of the cable only with a free terminal at the other; this latter arrangement gives the higher voltage. The traveling wave is assumed to enter at the "near" end of the cable and the voltage at the "far" end is calculated, since in general the maximum voltage will be found at that end. Reduction of the wave by cable losses is neglected, as tests have shown the losses to be small in 500-ft and 1,000-ft lengths of cable.

Among the results brought out in this paper are the following:

1. Short wave fronts do not greatly affect the ultimate voltage resulting in the cable.
2. Cable voltage is greater for waves which decrease more slowly with time. This difference is more pronounced for the shorter lengths of cable.
3. A higher surge impedance of the line results in a lower voltage in the cable. This effect is greater with longer cables.
4. Cable voltage varies widely with different cable surge impedances, the voltage decreasing with the impedance.

A practical example is worked out in the paper, and suggestions are made for lightning arresters to limit the high voltage impulses. **(A.I.E.E. paper No. 32-118)**

Voltage Regulation of Cables Used for Low Voltage A-C Distribution

By
H. R. Searing[7,8]
E. R. Thomas[7]

DISTRIBUTION of alternating current at low voltages does not depend primarily upon the selection of a conductor size which is thermally adequate, but depends upon the voltage regulation limits which will be satisfactory for lighting, especially when combined lighting and power loads are carried on the same circuit. Voltage regulation of a-c circuits is a function of the magnitude of the current, the power factor, and the circuit impedance. With currents of lower power factor, the inductance component of the impedance becomes the major parameter affecting the voltage regulation, and for a particular circuit and load, there is an optimum ratio of resistance to reactance. While the resistance per unit length of circuit is variable, depending only upon the physical size of the conductor, the reactance per unit length is almost independent of the physical size of the conductors, and for a single circuit with cables, can be changed only by changes in cable construction.

Thus in order to obtain a certain optimum ratio of resistance to reactance for a circuit, there are in general 3 courses of attack; first, for a given physical size the reactance component may be changed by changing the cable construction (the use of single conductor cable or multi-conductor cable employing either sector or concentric construction); second, by changes in the physical size of the conductor; and third, by paralleling 2 or more circuits.

The relative voltage regulations of the different types of cable are given in curves presented in this paper, and it is shown that the regulation efficiency (that is, the amperes per 1,000 cir mils which will give one per cent voltage regulation per 100 ft on a 3-phase 4-wire 120–208-v circuit) improved with the smaller wire sizes of cable. It is further shown that the concentric type of cable has the greatest efficiency, the sector type the next best efficiency, and the single conductor the poorest efficiency, with the twin circuits of single conductor cable lying between the values for single conductor cable and sector type. These data are adjusted for cost of cable at the factory and installed in the field, and it is shown that of the sizes of cable usually found in practise, 500,000-cir mil concentric construction provides the most economical means for transmitting low tension alternating current where the cable is not required to be worked alive. For cable mains, however, where it is necessary to work on live cables, the use of twin circuit 4/0 single-conductor cables is the most economical. Various phase relations between the several conductors are discussed. Test results indicate close agreement with the calculated values. **(A.I.E.E. paper No. 32-119)**

Pulp Insulation for Telephone Cables

By
H. G. Walker[11]
L. S. Ford[12]

PULP INSULATION is a new type of insulation that has been developed to replace the well known spirally wrapped ribbon paper insulation in certain kinds of telephone cables. It consists of a continuous pulp sleeving formed directly on the wire by a modified paper making process. The raw material for this insulation is commercial Kraft pulp and its preparatory treatment in the beaters corresponds to that given in the regular paper making process.

The machine used to apply this pulp to the wire is a modified single cylinder paper machine equipped to insulate 60 wires simultaneously. The wires are taken from the supply spools by means of flyers so as to allow the brazing of the wire from a nearly empty spool to the wire on a conveniently located full spool. This gives continuous operation. The wires are fed to the machine through an electrolytic cleaner for the removal of residual drawing compound. The surface of the mold or paper forming mechanism is divided into 60 narrow portions in such a way as to form that many narrow sheets continuously. The wires are brought into contact with the mold in such a way that as it rotates and forms the sheets, a single wire is embedded in each sheet. These sheets and wires are transferred from the mold to a traveling wool blanket by the pressure of the couch roll. The traveling blanket carries the sheets and wires through the presses for dewatering and consolidating, and delivers them to the polishers where the sheet is turned down by a rapidly rotating mechanism into a cylindrical wet sleeve surrounding the wire. The moisture is driven from the wet insulation by passage through a box type electric furnace one end of which is maintained at a rather high temperature. The insulated wire then is taken up on spools ready for the twisting operation. The speed of the machine is about 130 ft per min.

The major difficulties in the process have been overcome and the

6. General Electric Company, Pittsfield, Mass.
7. The United Electric Light & Power Company, New York, N. Y.
8. New York Edison Company, New York, N. Y.
9. Western Electric Company, Inc., Baltimore, Md.
10. The Chesapeake and Potomac Telephone Co. of Baltimore City, Md.
11. Western Electric Company, Inc., Kearney, N. J.
12. Bell Telephone Laboratories, Inc., Kearney, N. J.

basic properties of the insulation have been determined. Equipment for the production of about 225,000,000 conductor feet per week has been provided and the entire output of 24 and 26 A.W.G. cables is being made in pulp.

These cables are designed to the same size as the ribbon paper cables which they replace and compare favorably with them in their electrical characteristics except that the mutual capacitance is slightly higher. The impairment in transmission efficiency due to the higher capacitance is more than offset, however, by the lower first cost of the cable.

Standardized installation practises are followed except that a boiling-out compound softer and more lubricating than paraffin wax, is required, particularly at low temperatures. A suitable compound has been found by adding paraffin oil to wax in varying proportions depending upon the temperature at the point of splicing. The anticipated savings have been realized in the operation of the commercial units and the further expansion of the uses of this insulation is being studied. **(A.I.E.E. paper No. 32-122)**

Some Phases of Electrical Testing in a Rubber Covered Wire Plant

By
C. W. Protzman[9]
W. M. Hill[9]

DEVELOPMENT of new machines and processes for the manufacture of rubber covered wire made possible "straight line" production methods, with the elimination of process stocks and storage. However, the advantages of this method of production were reduced by the fact that the standard water test applied to the finished wire did not lend itself to this method of production.

With this process a stock of wire must be kept in the test tanks for a minimum 12-hr period, and stored in racks for an additional drying period. This requires stocks of process material, and in addition, the water test equipment requires a relatively large area; also separate equipment is necessary for coiling the tested wire.

A combined testing and coiling machine therefore was developed which wound the wire in coils ready for shipment and simultaneously furnished an electrical insulation test of the dry or "spark" type. The "spark" test involves the impression of a relatively high a-c voltage upon the insulation of the wire under test, with its conductor grounded. The entrance of a defect into this high voltage zone permits a flashover which actuates control apparatus to give an audible and visual signal and to stop the passage of the wire.

The circuit consists fundamentally of a specially built low power transformer with a condenser in the high voltage circuit to boost the commercial frequency to several hundred cycles when this circuit is closed suddenly. The signal and control apparatus is connected in the low voltage circuit. The voltage is impressed on the wire by means of an electrode approximately 5 ft long through which the wire passes, and the defect is located accurately for patching or removal by means of a small fault locator or electrode which is placed beyond the testing electrode.

Results of comparative checks on a large quantity of wire over an extended period indicated that the "spark" test performed more consistently than did the comparable water test. It is apparent that wider application of this method may be made by the entire rubber covered wire industry. **(A.I.E.E. paper No. 32-120)**

Use of Cables for Telephone Distribution Purposes

By
M. C. Rose[10]
H. A. Russell[10]

TELEPHONE CABLES containing large groups of insulated conductors in a common sheath have been developed rapidly since 1882; previous to that time all telephone distribution was by means of overhead wire plant. The present maximum sized cables in use contain 1,818 pairs of 26-gage conductors in a sheath having an outside diameter of $2^5/_7$ in. The increase in the amount of cable in plant during the past decade in certain metropolitan areas, such as Baltimore, Md., and Washington, D. C., has been over 100 per cent, and at the present time the value of the cable plant represents about 25 per cent of the total plant investment in these areas.

The type of cable distribution whether underground, aerial, attached to building walls, or located in buildings, depends generally upon the character of the area to be served and the station density. A complete system of records continuously maintained is an essential in the design of the distributing plant. The more important features of economical design include the gage requirements for transmission, the provision of facilities to care for existing business, and sufficient spare at the proper locations to care for reasonable expectations of growth.

The uses of telephone cable for distribution purposes in typical metropolitan areas, such as Baltimore and Washington, is outlined in this paper, including some historical background as to the development of cable and the part it takes in the present over-all plant investment. The division of metropolitan areas into central office areas and the various types of distribution are discussed. The engineering procedure followed in the design of cable distributing plant to provide economically a metallic cable circuit of satisfactory transmission quality for each subscriber's line to connect with the central office, involves the consideration of many factors. **(A.I.E.E. paper No. 32-121)**

Safe Harbor Project

By
N. B. Higgins[13]

DELIVERY of power to Baltimore, Md., from the first unit of the Safe Harbor hydroelectric plant on the Susquehanna River, began December 7, 1931, 20 months and 7 days after active work was started on the project site—an outstanding achievement in the annals of hydroelectric construction. The drought that prevailed during the construction period and the absence of high floods were important contributary factors to the speed with which the work was executed. In an average year, the Safe Harbor plant will generate over 800,000,000 kwhr, resulting in an annual coal saving in excess of 500,000 tons.

In the lower Susquehanna basin between Columbia, Pa., and the Chesapeake Bay, there is a difference of elevation of about 227 ft. The initial development, now known as the Holtwood project, went into operation in 1910, and left available for future development a fall of about 100 ft below and 57 ft above Holtwood. The lower development, commonly known as the Conowingo project, was constructed and went into operation in 1928. The development of the head between Holtwood pool and Columbia, known as the Safe Harbor project, is the subject of this paper.

The various features in connection with this project are discussed in detail. These include the reservoir conditions, hydraulic structures, forebay, power house, and electrical features. A major problem in electrical design at Safe Harbor has been to provide a flexible layout which will permit the installation as required of equipment for generation, transformation, and transmission at 60 cycles 3-phase, and 25 cycles single-phase. The plant is of the most modern design throughout, incorporating many novel features. **(A.I.E.E. paper No. 32-123)**

Safe Harbor-Westport 230-Kv Transmission Line

By
E. Hansson[13]

SAFE HARBOR development will have an ultimate capacity of 510,000 hp, a large portion of which will be available for Baltimore. During certain periods Baltimore will be dependent primarily upon this Safe Harbor power; therefore, reliability of transmission is of the utmost importance. The selection of the operating voltage was made only after a thorough investigation of the relative economic and reliability factors involved, the possibility of future interconnections, and system stability. Studies made in conjunction with the engineers of the Consolidated Gas Electric Light and Power Company of Baltimore covered a comparison of 2 23-kv circuits with 6 110-kv circuits. These studies also in-

13. Pennsylvania Water & Power Company, Baltimore, Md.

cluded investigation of such problems as terminal location, 2-point versus single-point supply, the use or omission of high voltage buses, and amount of synchronous condenser capacity required. An a-c calculating board was employed to check the results obtained by analytical methods.

The decision was made finally in favor of the higher voltage as offering lower cost, greater reliability, and greater possibilities for interconnection. Voltage regulation on the city network and control of short-circuit currents made power delivery to each side of the city advisable.

A brief description of the design of the Safe Harbor 230-kv transmission lines is presented in this paper. Attention is called to the separate routes of the 2 lines connecting the generating plant with the load center at Baltimore. The lines are the most heavily insulated so far constructed, and the ground wire protection has been applied according to the latest theory. Special effort has been made to reduce tower to ground resistances. Conductor tension has been kept low and armor rods are used at all suspension joints to guard against vibration troubles. The type of concrete anchors used lessens construction costs and facilitates erection of towers.

After comparing various designs, a 795,000-cir-mil A.C.S.R. conductor was chosen. Much has been said about the frailty of A.C.S.R. and about the precautions needed to protect it against damage. The Safe Harbor line was strung without any special safeguards, yet it stands completed with only 3 repair sleeves, and 2 of those could have been left off. **(A.I.E.E paper No. 32M16)**

Reception and Distribution of Safe Harbor Energy in Baltimore

By A. S. Loizeaux[15]

ENERGY from the Safe Harbor development was first received in Baltimore during December 1931, and at once took an important place in the energy supply of this city. Baltimore has both 25-cycle and 60-cycle loads, the maximum 25-cycle load recorded being 125,400 kw, the maximum 60-cycle load being 104,800 kw, and maximum simultaneous load on both frequencies being 188,200 kw. The 25-cycle frequency was originally chosen for industrial purposes and for the operation of rotary converters, although in recent years growth on this frequency has been held back. Shortly after completion of the Safe Harbor-Westport transmission line the frequency at Baltimore was changed from the former value of $62^1/_2$ cycles to 60 cycles, and the older frequency changers were shut down. One 30,000-kw frequency changer at Westport now takes care of all energy interchanged between these 2 systems. The characteristics and control of this frequency changer are described in the paper.

A bank of surge proof transformers of 126,000-kva capacity step down the Safe Harbor energy from 230 kv to 33 kv in a new outdoor substation. This 33-kv system ties into the 2 principal steam generating stations in Baltimore, and through them to the transmission system, chiefly of 13 kv, extending to Baltimore substations and surrounding territory. The main features of these transmission systems are described in the paper. **(A.I.E.E. paper No. 32-126)**

Low Head Hydroelectric Developments

By A. V. Karpov[14]

THE DESIGN of an up to date low head hydroelectric power plant requires a thorough understanding of the ideas and theories that have originated within the past few years in connection with such developments. The present paper is an attempt to review the latest work and to show some of the changes that have been made in the design of low head plants.

In the eastern part of the United States, and to a greater extent in Europe, power sites that could be developed economically by the use of conservative Francis-type turbine are diminishing rapidly. Many of the remaining low head sites can be developed only by the use of more economical methods; that is, by turbines of the propeller and, particularly, the Kaplan type. Kaplan turbines have been in commercial use only for the past few years, the units at the Safe Harbor plant being among the largest of this type. It is stated that the development of this type of turbine was accomplished entirely in Europe.

Various types of low head turbines are discussed in this paper, including the various theoretical and practical considerations which must be given each installation. Comparisons of European and American designs are given and future trends are indicated. It is stated that the runner blades and, in general, all parts of the runner which come in contact with flowing water in the Kaplan units at the Ryburg-Schworstadt plant, Germany, are machined and polished. In contrast to this the steel castings smoothed only by hand or by emory wheels at Safe Harbor probably represent a lack of proper machining equipment in the United States. The low setting of the center line of the runner at Safe Harbor, that is, 6 ft below normal tail-water elevation, probably is due partly to this deficiency. The paper indicates future trends in design. **(A.I.E.E. paper No. 32M15)**

Safe Harbor Kaplan Turbines

By L. M. Davis[16] G. W. Spaulding[16]

ONE of the numerous features of more than usual interest at the Safe Harbor hydroelectric development is the application of the Kaplan type of automatically adjustable blade propeller turbine. This type of turbine is used in all 6 units of the initial installation, each unit rated at 42,500 hp under a rated head of 55 ft. Safe Harbor is the first installation in America of Kaplan type turbines of large capacity, although they have been used for low head developments in Europe since 1919.

Many new and interesting problems arose in connection with these Safe Harbor turbines requiring, as with any pioneering development of this magnitude, an unusual amount of experimental and engineering study involving not only the hydraulic and mechanical design of the plant but affecting the structural and electrical design as well. The absence on this continent of a hydraulic testing laboratory in which cavitation tests could be made resulted in the construction of such a laboratory at Holtwood, Pa., adjacent to the Holtwood hydroelectric plant.

In addition to describing the laboratory at Holtwood and the tests carried out there, the paper includes the reasons for installing Kaplan units at Safe Harbor, together with a description of these units. In the laboratory, particular attention was given to cavitation, the phenomena resulting when a vacuum is formed under the runner blade. Tests on a complete model of the Safe Harbor intake, scroll case, wheel setting, runner, and draft tube, were made to determine within very close limits the highest elevation at which the runner could be set without danger of serious cavitation, for the maximum turbine power desired.

After deciding upon the general design of tube, further studies were carried out along 3 lines: First, the determination of the most economical length of the horizontal section of the tube; second, the determination of the maximum upward turn of this horizontal leg which could be considered without sacrificing efficiency; and third, the determination of the proper area at the discharge end of the tube.

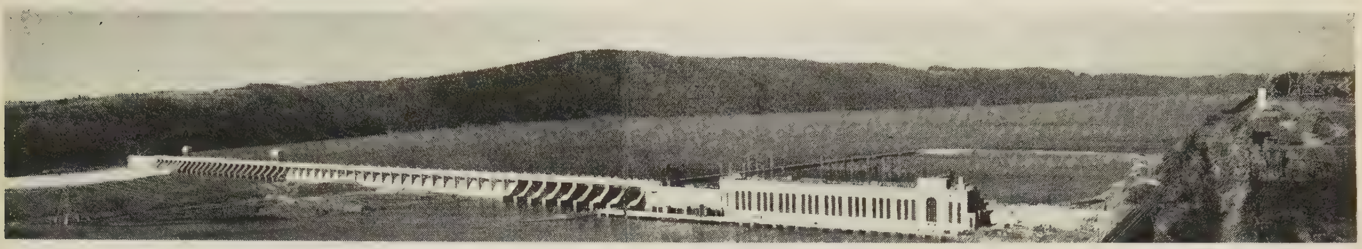
The test program has resulted in numerous improvements in operating performance, and savings in construction costs. Engineers of the 2 turbine manufacturers cooperated in jointly developing and manufacturing turbines of identical design wherein practically all replaceable parts are interchangeable.

The first 6 months of actual performance indicate that the prediction of the cavitation limits is reasonably close, although a considerably longer period will be necessary definitely to establish a close correlation between laboratory and field results. **(A.I.E.E. paper No. 32-124)**

14. Aluminum Company of America, Pittsburgh, Pa.
15. Consolidated Gas, Electric Light and Power Company of Baltimore, Md.
16. Safe Harbor Water Power Corporation, Baltimore, Md.

News

Of Institute and Related Activities



Safe Harbor development on the Susquehanna River. This plant of the Safe Harbor Water Power Corporation will be visited during the coming Middle Eastern District meeting of the Institute in Baltimore, Md., October 10–13, 1932, and is the subject of several interesting papers to be presented. Six Kaplan type turbines, each rated 42,500 hp under a head of 55 ft, are installed in this plant and are the first large Kaplan type units to be installed in this country

Baltimore Meeting Program Includes Interesting Features

CABLES both for power and for telephone use, and hydroelectric developments with particular reference to the Safe Harbor plant of the Safe Harbor Water Power Corporation on the Susquehanna River, are the outstanding features of the technical program arranged for the Institute's Middle Eastern District meeting to be held in Baltimore, Md., October 10–13, 1932, with headquarters in the Lord Baltimore Hotel. Inspection trips and entertainment features round out the program and assure a worth while meeting in this most interesting city.

Technical Sessions

Four technical sessions will be held during the meeting. The first session is under the joint auspices of the A.I.E.E. and the National Research Council, with Dr. J. B. Whitehead presiding; it will deal with timely cable problems, namely, economics, thermal transients, and traveling wave voltages. Also, the paper describing the Columbia River 115-kv oil filled submarine cable installation is of particularly noteworthy interest.

The second session will present a group of papers on design, fabrication, test, and use of telephone cables, and should prove of wide interest. The third and fourth sessions will treat waterpower development with particular reference to the Safe Harbor plant, including transmission and utilization of the energy; they will also describe the research activities at the Holtwood hydraulic laboratory that culminated in the design of the turbine at Safe Harbor for operation at high efficiency under partial load and with variable head. The generating units at Safe Harbor, each rated at 42,500 hp, represent the first installation of Kaplan type turbines of large capacity in America.

The National Research Council committee on electrical insulation has arranged an informal session at which results of recent research in the field of dielectrics and insulation will be discussed.

Inspection Trips

Among the inspection trips which have been arranged to various manufacturing plants, are those to the Bethlehem Steel Company's mills at Sparrows Point, the refinery and wire mill of the American Smelting and Refining Company, and the telephone cable plant of the Western Electric Company. A trip also will be made to the works and high voltage laboratory of the Locke Insulator Company where there will be a special demonstration involving 3,000-kv lightning impulses, and 1,000-kv 60-cycle waves. A special excursion will be made to the Safe Harbor hydroelectric plant where the Kaplan turbines, step-up substation, 230-kv river crossing, and other interesting details may be inspected.

Other Features

Baltimore has so much of general and historic interest to offer visitors that a sightseeing and entertainment program of unusual interest will be provided, including for the women a trip to Annapolis, the 300-yr old capital of Maryland which still retains much of the charm of Colonial days. Golf and tennis features also have been arranged in abundance. Full details of the entertainment features planned for the meeting will be given in the program folder now being prepared. Hotel registration cards will accompany this folder.

A meeting of the board of directors will be held on October 13, 1932, in connection with this meeting.

Committees

The committees handling the various phases of the work in connection with the Baltimore District meeting are as follows:

District Meeting—W. B. Kouwenhoven, *chairman*, vice-president, Middle Eastern Dist.; G. S. Diehl, *secretary;* A. F. Bang, F. A. Connor, K. A. Hawley, C. N. Johnson, L. G. Smith, J. T. Walther, and G. L. Weller.

General—K. A. Hawley, *chairman;* J. Wells, *secretary;* J. R. Baker, A. F. Bang, G. S. Diehl, R. C. Faught, A. Hughes, W. B. Kouwenhoven, W. O. Peale, A. L. Penniman, Jr., and L. G. Smith.

Papers—A. F. Bang, *chairman;* J. R. Baker, W. B. Kouwenhoven, J. L. D. Speer, and J. B. Whitehead.

Hotel and Registration—L. G. Smith, *chairman;* J. M. Barry, C. A. Brunner, F. Hamburger, and J. L. Hildebrandt.

Banquet and Entertainment—W. O. Peale, *chairman;* G. S. Diehl, R. C. Faught, C. S. Fiske, D. G. Howard, R. H. Lang, A. J. Pates, and C. V. O. Terwilliger.

Transportation and Inspection—Adrian Hughes, *chairman;* E. W. Jahn, G. R. Page, A. Rusk, and I. B. Yeakle.

Printing and Publicity—A. L. Penniman, Jr., *chairman;* J. H. Davis, A. Hughes, R. L. McCoy, and J. Wells.

Golf—F. E. Ricketts, *chairman;* G. H. Gilbert and C. V. Woodward.

Finance—W. H. Meese, *chairman;* F. A. Allner, C. M. Cohn, J. H. Davis, and F. J. Irish.

Ladies—Mrs. J. B. Whitehead, *chairman;* Mrs. F. A. Allner, Mrs. D. G. Howard, Mrs. W. B. Kouwenhoven, Mrs. L. G. Smith, Mrs. C. V. O. Terwilliger, Mrs. R. L. Thomas, and Mrs. John Wells.

Program

All technical sessions will be held in the Lord Baltimore Hotel and are scheduled

on eastern standard time. Abstracts of all papers which at the time of this issue were definitely scheduled for presentation at the Baltimore District meeting are presented in this issue of ELECTRICAL ENGINEERING, p. 659–62.

Monday, October 10

9:00 a.m.—Registration

2:00 p.m.—Cables—A Joint Session of the A.I.E.E. and the National Research Council, Dr. J. B. Whitehead, *presiding*

THE COLUMBIA RIVER 115-KV OIL FILLED SUBMARINE CABLE, E. F. Pearson, Northwestern Electric Co., G. B. Shanklin, General Electric Co., W. R. Bullard, Electric Bond and Share Co., and S. B. Clark, Northwestern Electric Co.

THERMAL TRANSIENTS AND OIL DEMANDS IN CABLES, K. W. Miller, Utilities Research Commission and F. O. Wollaston, Commonwealth Edison Co.

VOLTAGE REGULATION OF CABLES USED FOR LOW VOLTAGE A-C DISTRIBUTION, H. R. Searing, The United Electric Light and Power Co. and The New York Edison Co., and E. R. Thomas, The United Electric Light and Power Co.

TRAVELING WAVE VOLTAGES IN CABLES, H. G. Brinton, F. H. Buller, and W. J. Rudge, Jr., General Electric Co.

Tuesday, October 11

9:30 a.m.—Telephone Cables—J. L. Dawson Speer, *presiding*

SOME PHASES OF ELECTRICAL TESTING IN A NEW RUBBER COVERED WIRE PLANT, C. W. Protzman and W. M. Hill, Western Electric Co., Inc.

PULP INSULATION FOR TELEPHONE CABLES, H. G. Walker, Western Electric Co., Inc., and L. S. Ford, Bell Telephone Laboratories, Inc.

USE OF CABLES FOR TELEPHONE DISTRIBUTION PURPOSES, M. C. Rose and H. A. Russell, The Chesapeake and Potomac Telephone Company of Baltimore City.

Tuesday Afternoon

A session of the committee on electrical insulation of the National Research Council, Dr. J. B. Whitehead, *chairman*, to be held at the school of engineering of The Johns Hopkins University. In this session the results of recent research in the field of dielectrics and insulation will be presented. Informal reports of progress will be presented by manufacturers, scientific societies, and governmental and university laboratories.

Wednesday, October 12

9:30 a.m.—Safe Harbor Development—A. F. Bang, *presiding*

*ECONOMIC ASPECTS OF WATER POWER, F. A. Allner, Pennsylvania Water and Power Co.

SAFE HARBOR PROJECT, N. B. Higgins, Pennsylvania Water and Power Co.

SAFE HARBOR-WESTPORT 230-KV TRANSMISSION LINE, E. Hansson, Pennsylvania Water and Power Co.

RECEPTION AND DISTRIBUTION OF SAFE HARBOR ENERGY IN BALTIMORE, A. S. Loizeaux, Consolidated Gas, Electric Light, and Power Company of Baltimore.

2:00 p.m.—Safe Harbor Development—J. R. Baker, *presiding*

LOW HEAD HYDROELECTRIC DEVELOPMENTS, A. V. Karpov, Aluminum Company of America.

SAFE HARBOR KAPLAN TURBINES—DESIGN OF SETTING AND CAVITATION LIMIT AS DEVELOPED AT THE HOLTWOOD HYDRAULIC LABORATORY, L. M. Davis and G. W. Spaulding, Safe Harbor Water Power Corp.

Wednesday Afternoon

The meeting of the National Research Council, committee on electrical insulation, will be continued at the engineering school of The Johns Hopkins University.

Thursday, October 13

Excursion to the Safe Harbor Plant

Note: Arrangements will be made for those desiring to return home promptly to connect with through trains at junction points.

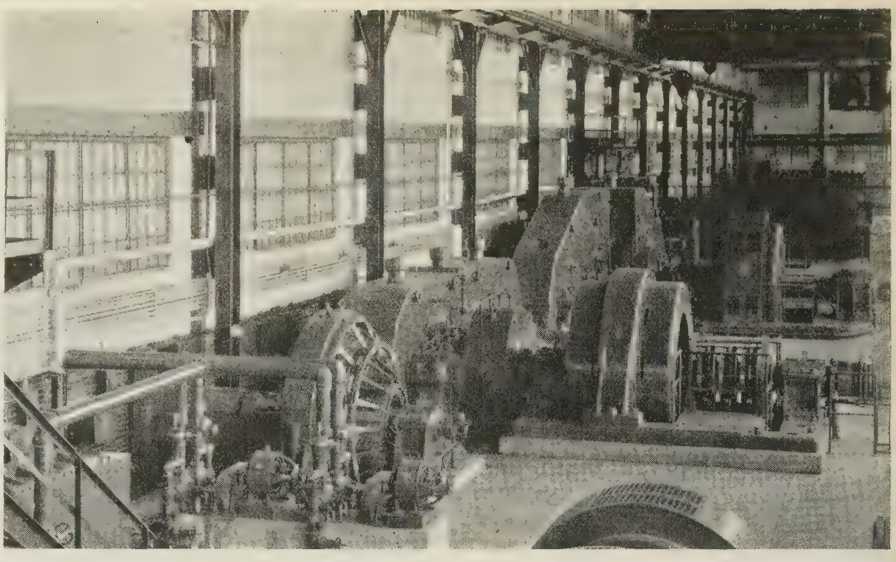
RULES ON PRESENTING AND DISCUSSING PAPERS

At the technical sessions papers will be presented in abstract, 10 minutes being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 minutes are allowed each discusser. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a 5-min. period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before Oct. 28, 1932.

* These papers are under consideration for presentation at the Middle Eastern District meeting, but up to date of going to press have not been officially placed upon the program.



The Sparrows Point, Md., plant of the Bethlehem Steel Company may be inspected by those attending the coming Middle Eastern District meeting of the Institute, October 10–13, 1932. Above is shown a general view of the motor room of the 27- 24- 21-in. continuous skelp and sheet bar mill in the Sparrows Point plant

1931 Proceedings of International Conference Published.—The full proceedings of the 1931 session of the International Conference on Large High Tension Electric Systems, held under the auspices of the International Electrotechnical Commission, has just been published (in French). They are in 3 bound volumes, 2,500 pages with 600 illustrations, are published by the International Conference, Avenue Marceau, 54, Paris, France, and cost 380 fr. Vol. 1 deals with generating and transforming equipment, vol. 2 with transmission lines, and vol. 3 with network operation, protection, and interconnection.

Pacific Coast Convention Reports

The Pacific Coast convention of the Institute being held at Vancouver, B. C., August 30 to September 2, 1932, cannot, of course, be reported in this issue of ELECTRICAL ENGINEERING, but a general news story covering convention activities is scheduled for the October issue. It is hoped also that written discussion of the Pacific Coast convention papers will be mailed to the A.I.E.E. editorial department, 33 West 39th Street, New York, N. Y., in sufficient time and in sufficient quantity to warrant the presentation of a review of discussion in the October issue; written discussions are due in New York on or before Sept. 16, 1932.

The program of the Pacific Coast convention was announced in ELECTRICAL ENGINEERING for July 1932, p. 518–9, and abstracts of all papers then scheduled for presentation were given in ELECTRICAL ENGINEERING for August 1932, p. 583–6.

Construction Reports for 1929.—Census reports of construction figures, compiled from data gathered in the census of distribution for the year 1929, show the construction business of the contractors in various states for that year. These construction reports are now available for a number of states, and are being compiled for remaining states. The bulletins are

obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for a nominal cost.

A.I.E.E. Directors Meet at Institute Headquarters

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., on Tuesday, August 2, 1932.

Present were: *President*—H. P. Charlesworth, New York, N. Y. *Past-presidents*—W. S. Lee, Charlotte, N. C.; C. E. Skinner, East Pittsburgh, Pa. *Vice-presidents*—K. A. Auty, Chicago, Ill.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; E. B. Meyer, Newark, N. J. *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; G. A. Kositzky, Cleveland, Ohio; A. H. Lovell, Ann Arbor, Mich.; C. E. Stephens, New York, N. Y.; A. C. Stevens, Schenectady, N. Y.; R. H. Tapscott, and H. R. Woodrow, New York, N. Y. *National Treasurer*—W. I. Slichter, New York, N. Y. *Acting National Secretary*—H. H. Henline, New York, N. Y.

The minutes of the directors meeting of June 22, 1932, were approved.

A report of a meeting of the board of examiners held July 27, 1932, was presented and approved. Upon the recommendation of that board, the following actions were taken upon pending applications: one applicant was transferred to the grade of Fellow, 4 applicants were elected to the grade of Member and 19 were transferred to the grade of Member; 31 applicants were elected to the grade of Associate; 11 Students were enrolled.

Announcement was made of the committee appointments made by the president for the administrative year beginning August 1, 1932, and various representatives were appointed by the board. (The list of committees and representatives is given in this issue of ELECTRICAL ENGINEERING, p. 678–80.)

In accordance with the by-laws of the Edison Medal committee, the board confirmed appointments to the committee made by the president, as follows: D. C. Jackson, chairman for the year beginning August 1, 1932; Gano Dunn, S. P. Grace, and C. E. Stephens, for terms of 5 years each. Also, the board elected from its own membership to serve for terms of 2 years each: J. Allen Johnson, A. E. Knowlton, and R. H. Tapscott.

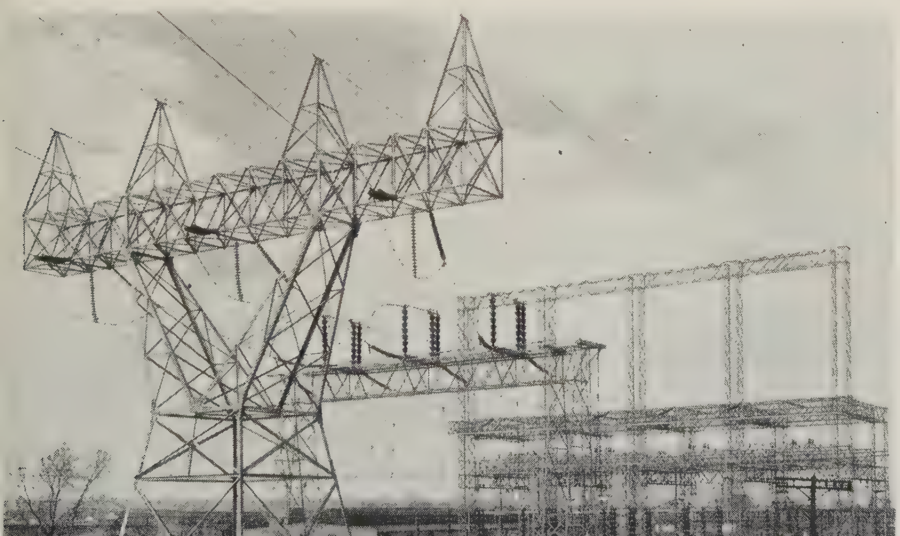
In accordance with the by-laws of the Lamme Medal committee, the board confirmed the following appointments by the president: P. L. Alger, H. B. Gear, and C. E. Skinner, for terms of 3 years each; C. E. Skinner, to serve as chairman for the year beginning August 1, 1932.

Local honorary secretaries were reappointed for the 2-yr term beginning August 1, 1932, as follows: V. J. F. Brain, for Australia; W. Elsdon-Dew, for Transvaal; A. S. Garfield, for France.

Various matters were discussed and referred to appropriate committees for consideration and recommendation.

Decision was made to hold the October meeting of the board of directors in Baltimore, Md., on October 13, 1932, during the Middle Eastern District meeting.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.



Substation at the Baltimore, Md., end of the transmission line from the Safe Harbor plant on the Susquehanna River. Energy is transformed from 230 kv to 33 kv at this substation, and distributed at the latter voltage to other substations located at load centers. This substation may be visited during the Middle Eastern District meeting in Baltimore, Md., October 10–13

Engineering Board Appointed for R.F.C.

President Hoover (HM'29) has named the board of engineers which is to pass upon the engineering adequacy of projects for which applications for loans are made to the Reconstruction Finance Corporation. The board of 6 members consists of Charles D. Marx, *chairman;* John F. Coleman, John Lyle Harrington, John H. Gregory, Herbert G. Moulton, and Major-General Lytle Brown. The chairman of the board was selected by the president and the other members were selected from a list submitted by American Engineering Council.

Each major geographical division of the country is represented on the board, and consideration was given the experience of the members along the lines that most of the applications for loans are expected to cover. The chairman, Charles D. Marx, is professor emeritus of civil engineering at Leland Stanford University, Calif., and occupied the chair of civil engineering at that institution from its establishment in 1891 until his retirement in 1923. He has done considerable consulting work and has served as chairman of the state water commission of California. He is an honorary member and past-president of the American Society of Civil Engineers.

John F. Coleman, New Orleans, Ala., has been in consulting engineering practise in that city since 1900, specializing in river and port projects, land reclamation, and railroad and utility valuation. He at one time was principal assistant city engineer of New Orleans, and also is a past-president of the American Society of Civil Engineers.

John Lyle Harrington, Kansas City, Mo., is a member of the consulting engineering firm of Harrington & Cortelyou, Kansas City. Since his graduation from college in 1895, he has been active in bridge work, and for the past 25 years he has carried on a consulting and designing practise. He is a past-president of The American Society of Mechanical Engineers.

John H. Gregory, Baltimore, Md., is a consulting engineer and professor of sanitary engineering at Johns Hopkins University. He has been in sanitary engineering work since his graduation in 1895, first in Boston with the metropolitan sewerage commission and the metropolitan water board, and subsequently in private practise in New York and Baltimore.

Herbert G. Moulton, New York, N. Y., is a consulting engineer specializing in reports for banking interests on railroad and mining operations and finance. During the War he served with the war industries board, and from 1915 to 1920 was advisor to the Public Service Commission of New York on timbering in the New York subways.

Lytle Brown, chief of engineers, U.S. Army since 1929, is an *ex-officio* member of the board. He has had wide experience

in government work both in the engineer corps and on the general staff of the Army, and is well known for his unusual executive ability.

Prominent Civil Engineer Dies

Charles Warren Hunt, who was secretary of the American Society of Civil Engineers from 1895 to 1920, and then upon retirement from active service was elected secretary emeritus of that organization, died on July 23, 1932. He was born in New York, N. Y., in 1858, the son of an eminent lawyer, and in 1876 was graduated from a civil engineering course at New York University. In 1909 his alma mater conferred the honorary degree of doctor of laws upon him.

After a few years in varied engineering positions, Mr. Hunt was appointed assistant secretary and librarian of the A.S.C.E. in 1892, and in 1895 became national secretary of that organization. In this capacity he was untiring in his efforts to promote the good of the engineering profession, and many important accomplishments may be attributed to him.

Lincoln Arc Welding Prize Award.—A jury under the direction of Prof. E. E. Dreese (M'25) of Ohio State University, Columbus, awarded the prizes for papers in the second arc welding prize competition sponsored by The Lincoln Electric Company of Cleveland, Ohio. First prize of $7,500 was awarded to Lt.-Com. H. N. Wallin, U.S.N., and Lt. H. A. Schade, U.S.N., jointly for their paper "The Design and Construction of an Arc Welded Naval Auxiliary Vessel." Second prize of $3,500 was awarded Maj. G. M. Barnes, U.S. Army, for his paper "Manufacture of Ordnance at Watertown Arsenal Revolutionized Through Arc Welding." The third prize of $1,500 was won by H. H. Tracy (A'26), of the Southern California Edison Company, Ltd., Los Angeles; the fourth prize of $750, by G. F. D. Wahl and H. E. Johns, Kiel, Germany; fifth prize of $500, by H. J. L. Bruff, Harrogate, England; and the sixth prize of $250, by W. H. Zorn, Wyandotte, Mich. Thirty-five additional prizes of $100 each were awarded to writers of papers showing the application of and saving possible by arc welding in every industry. Checks for the amounts of the 3 largest prizes were "written" on $^1/_8$ in. sheet steel; all information on the checks was arc welded, a submachine gun being used for cancellation.

Fast Escalators Move London Subway Crowds

Increasingly heavy traffic in the London, England, subways recently has rendered inadequate the type of escalators previously used. Improvement plans of the London (Underground) Electric Railway Company, Ltd., required an escalator which would be capable not only of vertical rises higher than those possible with the present standard escalator, but also capable of higher speeds to permit a more rapid handling of passengers. This resulted in designing and building a new escalator suitable for a maximum vertical rise of 90 ft., capable of a speed of 180 ft. per min. (twice that of the old escalators), and computed to be capable of handling 16,000 persons per hr (or double the number of the old).

A sample machine first was erected and put into operation in the Otis Elevator Company's works at Harrison, N. J. After the usual tests it was inspected by the engineers of the London (Underground) Electric Railway Company, Ltd., and 51 of these new machines were ordered. They are to be installed at various subway stations in London, and for vertical rises of from 24 to 90 ft.

This new escalator already is proving a remarkable success. The public is showing no hesitancy in accommodating itself to the higher step-speed, and of course the quicker transportation is popular.

—From an article appearing in *Electric Traction and Bus Journal* for June 1932, p. 253.

European Broadcasting Stations.—Information on broadcasting conditions in European countries has been furnished by A. H. Morton (A'24) European manager of the Radio Corporation of America. He states that while European broadcasting is still several years behind that in America in programs and technique, in the opinion of most observers the European equipment is good and programs are improving. Russia has three stations of 100 kw each; Warsaw, Poland, one of 150 kw; France has one of 100 and one of 80. Scattered through Germany and Italy are 50-kw stations. Broadcasting is still largely under state influence which takes various forms; but in Europe interest in commercially sponsored programs is growing in the countries where it is not forbidden by regulation.

Salary and Wage Reduction Survey Completed.—A report which should do much to set at rest the vast amount of speculation as to the extent and severity of salary and wage cuts throughout the country during the present depression has been issued by the National Industrial Conference Board, Inc. The statistics presented are based upon unusually comprehensive and complete returns from 1,718 business concerns of every nature except agricultural, personal, and professional pursuits. Among the large number of significant facts revealed in this analysis is that the smaller business and industrial concerns have made more drastic reduction in salaries and wage scales during the present depression than have the larger concerns. Executive sala-

Boulder City Emerges From the Status of a Construction Camp to a Complete City

© U. S. Bureau of Reclamation, Department of the Interior

Boulder City, Boulder Canyon project, Nev., organized to take care of the construction forces employed at Hoover Dam, is now the model construction city of the United States, and represents many of our national ideals. Comfortable homes have been built to house the workers and their families, dormitories and dining rooms have been constructed, schools, churches, and clubs completed, streets paved, and landscaping has been carried out on a large scale. A municipal organization has been set up under a city manager to assure adequate government for the population of over 3,000 employed persons and their families. Over 1,000 buildings have been completed, about 90 per cent of these being residences. Six Companies, Inc., owns the majority of these, although over 100 are owned by the government, and an approximately equal number by business permittees.

es have taken the greatest reduction, ith other salaries second, and wage rates ie smallest. It also is shown that on the verage, the companies making no reduction wages have had the smallest decline in nployment. Another significant fact brought out is that there was no general movement to reduce salaries and wages until the depression had gone into its second year. Also in contrast with earlier depressions, salary reductions have tended to precede wage adjustments.

Letters to the Editor

ONTRIBUTIONS to these columns are invited om Institute members and subscribers. They iould be concise and may deal with technical apers, articles published in previous issues, or her subjects of some general interest and prossional importance. ELECTRICAL ENGINEERING ill endeavor to publish as many letters as possible, ut of necessity reserves the right to publish them whole or in part, or to reject them entirely.

TATEMENTS in these letters are expressly unerstood to be made by the writers; publication ere in no wise constitutes endorsement or recogtion by the American Institute of Electrical ngineers.

Consumption, Production, Distribution

o the Editor:

What takes place to produce unemployient? First we will represent the circulaon of money in the form of the diagram,

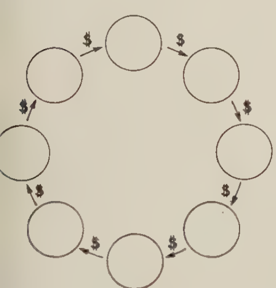


Fig. 1

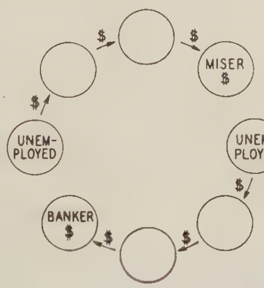


Fig. 2

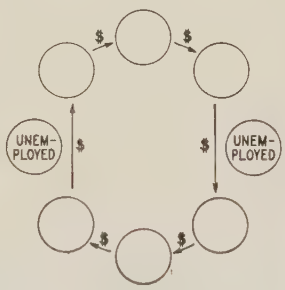


Fig. 3

ig. 1. In this case the money is shown rculating from man to man in a perfectly rganized society. Each man receives his irn at some of the money in return for ome kind of goods or services.

According to the theories expressed by ie progress report of the American Engiieering Council ("The Relation of Conimption, Production, Distribution," ELECRICAL ENGINEERING, June 1932, p. 373–9) iere is some form of stoppage to this flow money, which they describe by the exression that savings exceed investment. his hypothetical situation is shown by Fig. 2.

It seems entirely probable that there is ome action of this kind, and that business delayed by irregularities in the flow of oney. But that this irregularity should e enough to cause a depression of the agnitude of the present seems incredible. 'hat is more there is no evidence to suport the theory. We cannot demonstrate iat there was any greater irregularity in ie flow of money in 1930 than in 1928. 'e cannot point to the men who were olding back enough money to give emoyment to 5,000,000 people.

A more reasonable theory of unemployent is shown by Fig. 3. This shows a normal circulation of money, but some men are left out. Instead of having in our community a population of 8, representing perhaps 8,000,000, we have but 6 and the other 2 are outside. There is no reason why a community of 6,000,000 should not get along indefinitely just as well as a community of 8,000,000. And there is no force in our economic system to make the 6,000,000 gather in the other 2,000,000, for each one can spend all of his income by exchanging within his group. No one has anything left to hire the other outsiders.

The problem of unemployment is to find some way to induce the circle to open up and take in the outsiders, for the mere fact that the outsiders are there will not induce any individual in the group to trade or hire them. At present the limiting factor appears to be a shortage of capital. Furnishing capital is a service as much as furnishing labor. The supply of capital is only enough to permit the group to be of its present size. Should more capital be saved, some of the capitalists would seek the outsiders in order to get a better and more profitable use for their capital.

Very truly yours,
A. W. FORBES (A'12)
(Forbes & Myers, Worcester, Mass.)

(Editor's Note: This letter is the third by Mr. Forbes discussing the economic problems covered in American Engineering Council's progress report.)

To the Editor:

The special committee authorized by American Engineering Council in 1931 to study the relation between consumption, production, and distribution "interpreted its commission as being the selection and recommendation of such governmental, financial, and business policies as will maintain in the United States a standard of living that is high, broadly distributed, and free from severe fluctuations."

In attacking this problem the A.E.C. committee displayed excellent judgment in reducing the reputed number of factors bearing on the subject from 12 down to 8 and perhaps the most important of these 8 factors is that described in paragraph 5—"Controlling of money and credit to satisfy the needs of government, business, and individuals."

In publishing the full text of this A.E.C. committee progress report in the June 1932 issue of ELECTRICAL ENGINEERING, p. 373–9, the editors have rendered a time saving service by bracketing points that need emphasizing—for example that on p. 377 which will bear repeating:

"The stabilization of money is another possibility for large scale governmental and financial action. The seriousness of the lack of control of money value (or, the general price level as reckoned on a properly selected index) is beyond the power of words to express, because the world probably is in full movement on a secular decline with only minor short-lived upturns in prospect. It is important for governments and financiers to reconsider their attitudes on this question. A steadfast attempt to discover a safe and reliable means of controlling the value of money is required. Instead of being a question that is tabooed or ignored, it should be looked upon as the most important financial subject to which those in charge of the world's money can devote their energy and attention. There should be no rest until every possibility has been canvassed."

On p. 378 money and credit is involved in the A.E.C. committee's comments on public works, namely: "Herein lies an almost limitless field for the investment of private savings for public good that is socially profitable and economically stabilizing." In every relief bill offered, public works based on borrowed money have been discussed. Most of us believe that borrowed money should be repaid, and, as I write, the President's task of figuring out the rate of interest on borrowed money to be paid various parties, is the biggest point to be adjusted before the huge governmental relief bill receives his signature. Taxpayers are on the anxious seat and bankers who have the ready money (or will borrow some) must obviously figure risks as well as profits.

History records that Bellamy's book of the late eighties, "Looking Backward," inspired a hopefulness which was transferred into action by men in the electrical industry, and apparently history is about to repeat itself with hopeful plans transformed into action.

Here in Schenectady an electrical engineer from Pittsfield, Mass., recently outlined a plan involving the control of money and credit based on public works as a money standard which approached the subject in as business-like an engineering method as that employed by the A.E.C. committee in their recent progress report, and also inspired hope comparable with Bellamy's "Looking Backward."

Very truly yours,
H. W. TURNER (A'03)
(18 Troy Place, Schenectady, N. Y.)

Has Man Benefited by Engineering Progress?

To the Editor:

It seems to me that the Engineering Foundation's question "Has Man Benefited by Engineering Progress?" at once asks a question and answers it since "progress" applies only to a beneficial course of events.

An entirely different question would be "Has Man Benefited by Engineering Ac-

tivity?" This last question allows inclusion of the development of war machinery and hence its answer calls for a critical and exceedingly comprehensive scrutiny of our present civilization.

Very truly yours,

P. K. Seyler (A'26)
(Mountain States Tel. & Tel. Co., Denver, Colo.)

Magnet Steels and Permanent Magnets

To the Editor:

Under the title of "Magnet Steels and Permanent Magnets" an article was published by K. L. Scott in the May 1932 issue of Electrical Engineering, p. 320–3. I should like to make some remarks about this subject, explaining theoretically the experimental data of the work of Scott. Scott measures the induction B_{rem} in the middle of rectilinear bar magnets of different steels, lengths L and cross-sections A, and finds that $\frac{B_{rem}}{B_r}$ is only a function of $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$, where B_r = remanence in closed circuit, H_c = coercive force, L and D = equivalent diameter. Thus:

$$\frac{B_{rem}}{B_r} = \mathrm{f}\left(\frac{L}{D}\sqrt{\frac{H_c}{B_r}}\right) \qquad (1)$$

The form of this function is given in Fig. 2 of the article by Scott, which figure we reproduce here as Fig. 1.

Scott first tried to plot against $\frac{L}{D}\sqrt{H_c}$ but found it preferable to plot against $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$. We will show that the last method of plotting is the one to be theoretically expected.

The demagnetizing coefficient N of a rectilinear bar which is not too short compared to its cross-section is given by:

$$N = 4\pi\beta^2\left(\log\frac{2}{\beta} - 1\right) \qquad (2)$$

where $\beta = \frac{D}{L}$ (this formula is valid exactly for an ellipsoid and for β small).

N being known for a special bar, we find

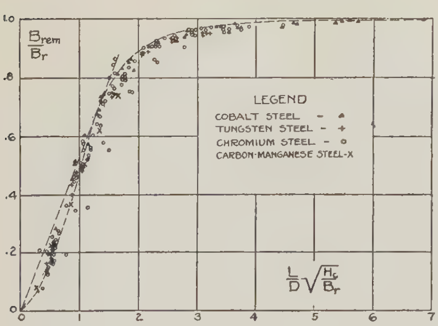


Fig. 1

the remanence B_{rem} in the middle of the bar, as Fig. 2 shows, as the intersection point P of the line S and the demagnetization curve, if $\tan\alpha = \frac{H}{B} = \frac{N}{4\pi}$ (divided by 4π because we plot $B = 4\pi\,\mathscr{I} + H$ instead of $\mathscr{I}$, which is the intensity of induced magnetization).

Now experiments of R. L. Sandford (Bureau of Standards scientific paper No. 567 published in 1927) show that the demagnetization curves of all steels have nearly the same shape. If we therefore transform Fig. 2 into Fig. 3 by introducing the variables $\frac{B}{B_r}$ and $\frac{H}{H_c}$ instead of B and H, respectively, the demagnetization curves of different steels fall on the same curve. In Fig. 3 we draw the line S making the angle α' with the ordinates:

$$\tan\alpha' = \frac{H/H_c}{B/B_r} = \frac{H}{B}\times\frac{B_r}{H_c} = \frac{N}{4\pi}\times\frac{B_r}{H_c}$$

The point P gives the value of $\frac{B_{rem}}{B_r}$ in the middle of the bar and as the demagnetization curve of Fig. 3 is valid for all steels, the value of $\frac{B_{rem}}{B_r}$ is only a function of α', that is, of $\frac{N}{4\pi}\times\frac{B_r}{H_c}$.

Thus:

$$\frac{B_{rem}}{B_r} = \varphi\left(\frac{N}{4\pi}\frac{B_r}{H_c}\right) = \varphi\left[\beta^2\left(\log\frac{2}{\beta} - 1\right)\frac{B_r}{H_c}\right]$$

In first approximation we neglect the variation of $\left(\log\frac{2}{\beta} - 1\right)$ so that we write:

$$\frac{B_{rem}}{B_r} = \varphi\left(A\beta^2\frac{B_r}{H_c}\right) = \varphi\left(A\frac{D^2}{L^2}\frac{B_r}{H_c}\right) = \mathrm{f}\left(\frac{L}{D}\sqrt{\frac{H_c}{B_r}}\right)$$

$\frac{B_{rem}}{B_r}$ is thus a single-valued function of $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$ as long as $\left(\log\frac{2}{\beta} - 1\right)$ may be considered as constant, and for values of β

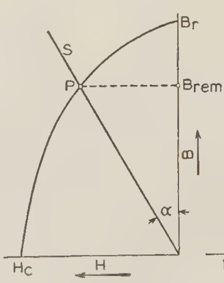


Fig. 2

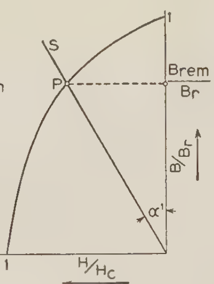


Fig. 3

not too large, because for large β, eq. 2 does not hold.

As shown experimentally by Scott, the line in Fig. 1 through the origin and tangent to the curve has its point of tangency in the point corresponding to the point of maximum economy on the demagnetization curve (i. e., the point where $B \times H$ is at its maximum).

To show this and to calculate the function $\mathrm{f}\left(\frac{L}{D}\sqrt{\frac{H_c}{B_r}}\right)$, that is, to calculate the curve of Fig. 1 we must make an assumption regarding the shape of the demagnetization curve. I found good agreement with experiment (see W. Elenbaas, Physica, v. 9, 1930, p. 273) by taking the demagnetization curve as a quadrant of an ellipse. Therefore we write the equation of the demagnetization curve as:

$$\frac{H^2}{H_c^2} + \frac{B^2}{B_r^2} = 1 \qquad (3)$$

We find B_{rem} as the intersection point of this ellipse with the line S (Fig. 2). The equation of S is:

$$\frac{H}{B} = \frac{N}{4\pi} = \beta^2\left(\log\frac{2}{\beta} - 1\right)$$

In first approximation we regard $\left(\log\frac{2}{\beta} - 1\right)$ as constant.

Thus:

$$\frac{H}{B} = \beta^2 A \qquad (4)$$

Eq. 3 and eq. 4 give:

$$B^2_{rem} = \frac{1}{\frac{A^2\beta^4}{H_c^2} + \frac{1}{B_r^2}}$$

$$\frac{B^2_{rem}}{B_r^2} = \frac{x^4}{A^2 + x^4} \text{ if we take } x = \frac{L}{D}\sqrt{\frac{H_c}{B_r}}.$$

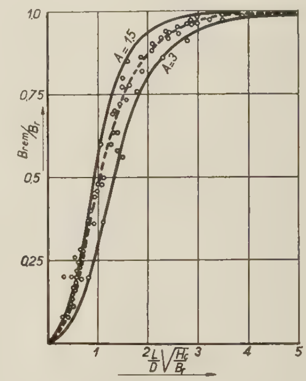


Fig. 4

Here again we find that $\frac{B_{rem}}{B_r}$ is only a function of x and for the form of that function we find:

$$\frac{B_{rem}}{B_r} = \frac{x^2}{\sqrt{A^2 + x^4}}$$

Indeed this is a function similar to the curve of Fig. 1. In Fig. 4 we draw this function for 2 values of A, namely $A = 1^1/_2$ and $A = 3$, these being about the extreme values of A in the experiments of Scott. The experimental points (a large number of the points of Scott are plotted in Fig. 4) fall satisfactorily between these 2 curves, except some points at low values of x. This is probably due to the fact that β for these bars was so great, that eq. 2 did not hold (the greatest value of β used by Scott was about $\frac{1}{5}$).

We find the point of tangency of the curve $\frac{B_{rem}}{B_r} = \frac{x^2}{\sqrt{A^2 + x^4}}$ with the line through the origin by making $\frac{B_{rem}}{xB_r} = \frac{x}{\sqrt{A^2 + x^4}}$ a maximum.

This gives $x = \sqrt{A}$ and therefore

$$\frac{B_{rem}}{B_r} = \frac{A}{\sqrt{2A^2}} = {}^1/_2\sqrt{2}$$

and in the case of an ellipse this corresponds indeed to the point of the demagnetization curve, where $B \times H$ is a maximum. The value ${}^1/_2\sqrt{2} = 0.7$ is in good agreement with the experimental value derived from the curve of Fig. 1, namely 0.65.

In this way it is possible to interpret fully the curve as found by Scott.

Very truly yours,

W. Elenbaas
(Natuurkundig Laboratorium der N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland)

Savings and Investment

To the Editor:

Mr. Forbes in his letter printed in the July 1932 issue of ELECTRICAL ENGINEERING, p. 527, regarding the American Engineering Council's progress report on consumption, production, and distribution, apparently put his finger on the sore spot without knowing it.

Referring to his illustration, suppose Mr. Smith keeps the $3, saves it. Mr. Brown keeps the hat. Brown may be the owner of the hat factory, Smith his employee. Anyhow, Brown has goods for sale, Smith is a prospective consumer, who has earned $3. No business is done, and we have "depression." Now if Smith's saving is invested, it goes to work, is paid to some one for building "capital goods," and a second consumer has the $3 and can buy the hat. The important thing is obviously movement, not a static equation showing the status of any particular $3 at any particular instant. The time element must be introduced.

The difference between savings and investment in the report is crucial; and the integration of these items over a time period (or else the rate with respect to time) is implied. It simply means finding the spot where the system is clogged. The volume of trade is forced to decelerate by diversion of purchasing power into the reservoir of hoarded wealth.

Where this hoarded wealth may be found has been disclosed by much material recently published. Another way of saying this is that there was a contraction of currency and credit. This did occur in 1929, contrary to Mr. Forbes, and the process has continued since then. The details involve an insight into our banking and credit structure, which is beyond the scope of this letter.

Very truly yours,
C. T. BUTTON (A'26)
(1133 Chamber of Commerce Bldg., Cincinnati, Ohio)

Young Engineers Must Plan for the Future

To the Editor:

For a number of years I have been endeavoring to interest the most promising among our electrical engineering seniors and graduate students in thinking of our profession 10 to 20 years ahead of their time. It usually takes that long for a natural leader to reach a position in which he can actually lead a considerable group of workers. I always wanted such men to get at least a general idea of the directions in which our art and industry were moving at the time, so as to acquire the necessary mental equipment in the meantime. In 1905 I talked to them of huge transmission lines and of the necessity of understanding how to compute them both electrically and mechanically. About 1910 we had a chosen group struggling with transient phenomena and with plotting of electric and magnetic fields. In 1915 I used to annoy my graduate students by incessantly talking about electrons and about the important rôle they were going to play in electrical engineering. Then came the Heaviside calculus, power plant stability, thermionics, and what not.

For years this country has been handicapped in the development of electrical apparatus and in understanding some operating troubles by the false belief (natural in a pioneer country with only 2 political parties) that physicists, chemists, and mathematicians discover and investigate fundamental laws upon which the art of the engineer is based, and we engineers merely apply these laws and data to our problems. The Germans have developed a much more practical and flexible hierarchy of pure scientists, applied scientists, theoretical engineers, and practical engineers, with almost imperceptible gradations among them. The result has been that in Germany an operating trouble can be handed down (or perhaps up) from a practical engineer to a theoretical engineer; from the latter, in a modified form, to an applied scientist, and sometimes in the form of a general problem even to a pure scientist. With us, until a few years ago, if an operating engineer had trouble with some oil or paint he had to lay his story before a professor of chemistry who was liable to talk to him in terms of hydroxi-derivatives of phenanthraquinone, leaving the operating man exactly where he was before. It was partly this unsatisfactory situation which finally led to the formation of large research departments in our leading manufacturing and operating organizations. Nevertheless, there are still numerous gaps in many places. We need several types of middlemen between the pure sciences and the engineering art, and we need them urgently. Probably such intermediate men are also needed in economics and psychology, but this is another story for some one else to discuss.

It is with this idea in mind, namely, to increase the number of young theoretical engineers and applied scientists in this country, that I now urge intelligent students and former students to look forward not to an immediate job (or absence of one, as the case may be), but to a time when our industry shall demand an intelligent judgment about the group theory and restricted relativity in mathematics, theoretical spectroscopy and wave mechanics in physics, and an interpretation of the molecular structure and chemical reactions in terms of the quantum theory. All this may sound far fetched, but I remember the time when only a few chosen ones could handle alternating currents in terms of ordinary trigonometry, and when a d-c network computed by Kirchhoff's laws was sometimes checked on a small model, "just to be sure."

It is an ill wind that blows nobody good, and in these days of adversity and depression an ambitious young engineer with scientific leanings can do no better than to study the fundamental sciences and thus prepare himself for a place of middleman and interpreter in some specific problem of the industry of the future. The general tendency undoubtedly will be in the direction of more reliance on pure sciences, more accurate predetermination of performance of apparatus, and a rational analysis of troubles. No matter in which suitable branch of mathematics, physics, chemistry, or mechanics he decides to become an expert, he will be working toward ultimately becoming "geared" to the industry in an organic way, whereas one who shall place his reliance mainly upon good health, pleasing sociable personality, and a general idea of what a shunt wound d-c machine is, may later find himself in a long line of applicants with similar qualifications, all waiting for the same 15-dollar-a-week job. With the dawning socialization of the industries, the days of the glib-tongued salesman and prosperity manager are about over, and the truly scientific engineer will be soon coming into his own.

This letter is not the place to indicate specifically which topics I consider to be of importance in the future. The very process of finding fruitful paths of pioneering is an important part of the proposed studies, as well as a test of one's fitness for future leadership. Whatever subject one undertakes to master must be organically (although perhaps yet in a hidden way) connected with the present progress of the art, and not merely join it at some distant future. Anyone who would take the trouble of going over the Institute TRANSACTIONS, say for the last 10 years, keeping the forthcoming trends in view, will find any number of inspiring hints and clues. A similar study of the leading European periodicals devoted to electrical engineering should be the next step. Then, having decided to follow, say, some features of the science of electronics, the best American journals of physics should be gone over, and finally a detailed program of study arrived at. After this, it is merely a matter of finding suitable books and perhaps forming a connection with an experienced specialist for guidance and advice.

Very truly yours,
VLADIMIR KARAPETOFF (F'12)
(Cornell University, Ithaca, N. Y.)

Suggested Changes in Dielectric Nomenclature

To the Editor:

I note with interest the increasing effort on your part to make our monthly publication a direct expression of the profession.

I am particularly interested in your publication of timely letters addressed to the Editor. I read with much interest a letter by Hubert H. Race (A'24) suggesting changes in dielectric nomenclature (see ELECTRICAL ENGINEERING for May 1932, p. 354–5). I approve Mr. Race's suggestions and believe there are many instances in which an improved nomenclature would make for clarity and convenience of expression in the electrical engineering art.

I have in mind a particular instance where I believe an improved nomenclature and the adoption of the name for a unit would be of advantage. I have in mind the unit of electric field intensity or voltage distribution per unit of length. This unit is now customarily expressed as volts per foot, or volts per inch, or volts per centimeter. I believe a single name for this unit, preferably called after some distinguished pioneer in this art, to be a desideratum.

I, therefore, take the liberty of proposing that the c.g.s. electrostatic unit of electric field intensity be called the "Franklin."

Very truly yours,
WM. W. FRASER (M'27)
(6 East 45th Street, New York, N. Y.)

Patents on Arc Welding Generators

To the Editor:

We refer to p. 527, July 1932 issue of ELECTRICAL ENGINEERING, "Letters to the Editor," entitled "Eliminating Transients in a D-C Welding Generator" and more definitely with regard to the public assertion that J. Bethenod now has a patent on this double wound reactor for controlling the arc in a welding generator. We would like to have this letter published.

The writer was granted U.S. Patent No. 1,549,874, August 18, 1925, on this scheme. The scheme was invented and improved to practise sometime previously and if the patent laws of France were similar to the laws of the United States, Mr. Bethenod would not have obtained any patent on this.

In deference to the insinuation against the other 2 leading companies in arc welding, both of these are licensed under our patent and are probably, accordingly, interested in Bethenod's later development because in this country the man who does it first obtains the patent, and if it has been published, patented, described, or used in any other country, no patent can be obtained in this country. The writer believes he was the first to discover the use of static transformer control of an arc welding generator.

This transformer arrangement of the old familiar series reactor is a wonderful improvement, theoretically and practically. In self-excited machines the discharge into the hands of the operator is dangerous. In separately excited sets, the insulation should be of a special nature to insure that this doesn't happen. The trouble lies in applying the induced voltage to the shunt field which has high values to counteract. The same effect can be had by applying this voltage to the series field and here the values are so low that many times them are still less than the arc voltage.

Very truly yours,

C. J. Holslag (M'19)
(President, Electric Arc Cutting & Welding Company, 152 Jelliff Ave., Newark, N. J.)

(Editor's Note: This letter is an extension of one phase of Mr. Holslag's letter which was published in Electrical Engineering for January 1932, p. 59.)

Standards

Proposed Electrical Definitions Now Available in Report Form

The report on the proposed "American Standard Electrical Definitions" upon which the sectional committee on electrical definitions has been working for over 3 years now is available in a pamphlet of 208 pages. The project, which had its initiation in 1928 in the recommendation of the A.I.E.E. standards committee, has been carried on in full accordance with the rules of procedure of the American Standards Association and under the sponsorship of the Institute.

This work required the formation of 17 subcommittees with a total personnel of about 120, the additional expert help sought increasing the number cooperating to over 300. The individual reports of the subcommittees have been widely circulated for criticism and comment in each of their several stages of development. Controversies on proper wording naturally have developed in many instances. In most cases, the subcommittees have been able to arrive at an acceptable solution within their own groups. In cases of overlapping fields the executive committee under the able guidance of Chairman A. E. Kennelly has been called into action. Even after the most earnest efforts to eliminate conflicting definitions, it will be noted that certain conflicts still exist. It was felt to be very desirable, however, to issue the report as it now stands with the hope that circulation in pamphlet form would result not only in obtaining still further suggestions of a helpful nature, but might lead perhaps to a solution of the questions still unsettled.

In collecting and compiling the definitions which served as the original basis of the committee's work, it soon became evident that there existed conflicting definitions of identical terms, all having the status of American standards. In most such instances the sectional committee on electrical definitions has selected what appeared to it to be the most desirable wording. In other cases it has been felt desirable to suggest for a term or concept a wording differing from an accepted standard. The object in view always has been the development for each term of a wording expressing the meaning generally associated with it in electrical engineering in this country. When possible, definitions have been generalized so as not to preclude the different specific interpretations attached to particular applications.

The sectional committee wishes to express its sincere appreciation of the spirit of cooperation which it has met on all sides, and acknowledges its indebtedness to all organizations and individuals having given so freely of their time and experience. The assistance obtained from glossaries issued by various technical organizations, particularly the British, and the experience of the secretariat on nomenclature of the International Electrotechnical Commission, have been particularly helpful.

The glossary in its present state is incomplete, but it is impractical to carry through the entire program at one time. The cost involved to date has been great; therefore it has been found necessary to make a nominal charge for copies. This price has been set at $1 per copy, with the usual 50 per cent discount to members of the A.I.E.E.

Address all communications to A.I.E.E. Headquarters, 33 West 39th Street, New York, N. Y.

Personal

H. S. Osborne (A'10, F'21) who is now transmission engineer of the American Telephone and Telegraph Company, New York, N. Y., is to continue his chairmanship of the Institute's technical committee on communication for the ensuing year. He was born at Fayetteville, N. Y. From Massachusetts Institute of Technology he received his B.S. degree in 1908 and his doctor of engineering degree in 1910. During his college course he engaged summers in engineering positions which gave him a varied experience. In 1910 he joined the engineering department of the American Telephone and Telegraph Company as engineer in the transmission and protection department. Here he assisted in many developments in telephone and telegraph engineering, including quadded cable and the systematic study of interference in telephone circuits. In April 1914 he was made assistant to the transmission and protection engineer, and in this new office assisted in the establishment of the transcontinental telephone. Under the general direction of the transmission and protection engineer he also was in responsible charge of many important developments. In 1920 he was appointed transmission engineer and as such has assumed the responsibility for assisting all companies of the Bell Telephone System in connection with telephone and telegraph transmission and protection matters, advising regarding the proper use of new developments and carrying out exhaustive studies to determine the most desirable plant practises. Mr. Osborne has served as representative of the Institute on the American Standards Association from 1923 to date, at one time being assistant treasurer of the A.S.A. He also has served on the A.I.E.E. standards committee 1917–28 (chairman 1923–26); committee on education 1928–31; communication committee 1929–32 (chairman 1931–32); technical program committee 1924–25, 1927–29, 1931–32; and upon the electrical standards committee

H. S. OSBORNE

of the American Standards Association as an alternate representative of the A.I.E.E. 1931 to August 1932, when he was appointed a representative. Mr. Osborne now is vice-president and treasurer of the U.S. national committee of the International Electrotechnical Commission with which he has worked for many years. His memberships include the American Physical Society, the American Association for the Advancement of Science, the Acoustical Society of America, Engineering Foundation, Institute of Radio Engineers, and the Montclair (N.J.) Society of Engineers, of which he is also past-president. His contributions to technical literature have been numerous.

E. J. Rutan (A'20, M'29) supervisor of the test bureau of the New York Edison Company, with which he has been associated for over a decade, has received reappointment as chairman of the Institute's technical committee on instruments and measurements for the current year. Brooklyn, N. Y., is Mr. Rutan's place of birth. After completing a course at Cornell University from which he received his M.E. degree with certificate in electrical engineering, he joined the test department of the New York Edison Company in 1919 as a tester. Within a short time he

K. L. HANSEN

S. L. HENDERSON

W. A. HILLEBRAND

E. J. RUTAN

ad advanced to foreman; then he became eneral foreman, assistant superintendent, nd ultimately superintendent. Since 1924 e has been in responsible charge of the ompany's test work. In 1930 the name f the test department was changed to test ureau and Mr. Rutan became supervisor; he work continued to cover all testing arried on by the company, including cceptance tests of all materials received n the store room, machinery for stations, nd all equipment for transmission and istribution systems. Also all special testng for development and research purposes s conducted in this bureau to maintain lectrical standards for the company in onnection with primary standard cells, esistors, and potentiometers. Mr. Rutan vas a member of the Institute's technical ommittee on protective devices, 1924–27; member of the subcommittee on standrds for measurements of voltages in dilectric tests, 1925–26; and in 1927 was ppointed to the subcommittee called to raft standards for constant current transormers; his appointment to the technical rogram committee took place in 1930. ince 1926 he has served on the instruments nd measurements committee, having been ts chairman since 1930. As a member of he American Society for Testing Materials, e has served on its committee D9 on elecrical insulating materials 1927–29, and ow again in 1932.

W. A. Hillebrand (A'08, M'13) preiously electrical engineer for the Ohio nsulator Company Division of the Ohio rass Company, at Barberton, Ohio, a osition which he had held since 1919, has eturned to the academic field and in August 1932 will assume new duties in accepting a professorship in electrical engineering at the University of California, Berkeley, Calif. In a consulting capacity however, he will continue his affiliation with his commercial interests. Graduating from Cornell University in 1905, Mr. Hillebrand extended his studies to include a year at Stanford University, Calif. Through employment in the Pacific Coast office of the Western Electric Company 1906–7, he continued to broaden his experience. The period 1907–14 was occupied as instructor under Doctor H. J. Ryan at Leland Stanford University and as professor of electrical engineering at the Oregon State College, Corvallis, Ore. In June 1914 he joined the Pacific Gas and Electric Company (Calif.); for 2 years he was engaged with the Federal Telegraph Company (Calif.) in the manufacture of arc radio transmitters. His first identification with the Ohio Brass Company at Mansfield, Ohio, was as a commercial engineer, still centering his activities upon the Pacific Coast, but traveling over all parts of the United States and Canada, even spending some 8 months in Japan. In 1925 he went to Barberton, Ohio, as consulting electrical engineer for the Ohio Insulator Division of his company, thus returning to his native State. Mr. Hillebrand's place of birth was Perrysburg, Ohio, but he grew up in Washington, D. C. Besides his membership in the A.I.E.E., he is a member of the Institute of Radio Engineers and also of the Schweizerisher Elektrolechnischer Verein of Zurich.

K. L. Hansen (A'17) now carrying on a consulting engineering practise in Milwaukee, Wis., under the company name of K. L. Hansen Engineering Company, Inc., has been appointed to serve as chairman of the Institute's technical committee on electric welding for the current year, a committee of which he has been a member for the past 2 years. Mr. Hansen was born in Norway and came to the United States early in 1901. For $2^1/_2$ years he worked in various shops in Chicago, most of the time for the Western Electric Company, assembling fan motors and arc lamps. In the fall of 1903 he entered the University of Illinois. From the summer of 1905 until early in 1906 he found employment with the Chicago Edison Company, first as splicer's helper in the underground cable department and later as substation operator. In February of that year he removed to East Pittsburgh, Pa., and joined the Westinghouse Electric and Manufacturing Company, working for a year and a half successively as wireman, tracer, and draftsman. His company then transferred him to the dynamo testing department where he remained for nearly 4 years or until he again was transferred, this time to the industrial engineering department, to become designing engineer for d-c motors and generators. He remained in the employ of the Westinghouse company until in the fall of 1919 he left it to join the Louis Allis Company (then the Mechanical Appliance Company) of Milwaukee. Here again he engaged in the capacity of designing engineer, this time for a-c and d-c motors and generators, later becoming chief engineer. It was upon severing his connection with the Louis Allis Company that he entered upon consulting and development work of his own. The Hansen arc welder, first built and marketed by the Northwestern Manufacturing Company, of Milwaukee, until the early part of 1932 and later taken over by the Harnischfeger Corporation of that city, was invented and designed by Mr. Hansen, whose own company, the K. L. Hansen Engineering Company, Inc., is now marketing it. He developed a number of arc welding processes, the Hansen arc torch being one of them. He also holds patents, jointly with another, on self-starting induction motors and self-starting compensated induction motors. During the past 5 years Mr. Hansen has given numerous addresses before technical societies and conventions, chiefly on the subject of arc welding and its many applications.

S. L. Henderson (A'12) division engineer of the power engineering department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and since 1928 a member of the Institute's technical committee on electrical machinery, has received reappointment as its chairman for the current term of service ending August 1933. Mr. Henderson is a native of Roxbury, Mass.; upon completion of his public school work in Boston, he entered Massachusetts Institute of Technology. In July 1910 he joined the test department of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, and by 1912 was holding a position of responsibility with that company. For a number of years he was in charge of turbine generator design for the Westinghouse company; his present work is in charge of design of large synchronous and induction motors. He also has been active as a committee-man for other technical bodies of professional importance, having served on the American Standards Association's sectional committee on rotating machinery; A.S.A. subcommittee on definitions; and subcommittee 1-C on wave shape, of the National Electric Light Association's joint committee on development and research in collaboration with the Bell System. In addition to his service on the electrical machinery committee of the A.I.E.E., Mr. Henderson has been active as a member of its subcommittee on synchronous machines.

W. C. SMITH (A'07, M'26) succeeds R. F. MONGES (A'08) to the position of district engineer of the San Francisco, Calif., office of the General Electric Company, June 1932. Mr. Smith has been with the company since 1905 in varying capacities, joining the organization the same year he was graduated from the University of Michigan. In 1907 he became a member of the transformer engineering department and until 1918 worked both at Pittsfield, Mass., and Schenectady, N. Y., supplementing this experience with 2 years spent in special investigations for his company at Denver, Colo., before taking office at San Francisco as transformer, meter, and regulator specialist. He has been Mr. Monges' assistant for the past year. In 1925 he was awarded the Coffin Medal, which is given annually by the General Electric Company, "for the most signal contributions toward increase in efficiency or progress in the electrical arts"; he is past-chairman of the company's Pittsfield Section, and recently was elected vice-chairman of the A.I.E.E. San Francisco Section, which he already has served during the past year as secretary. Other organizations to which he belongs are the San Francisco Electrical Development League, the San Francisco Engineers' Club, the Pacific Coast Electrical Association, and the Astronomical Society of the Pacific Coast.

W. J. MOWBRAY (A'03, F'31) previously operating as meter engineer at Cranston, R. I., and for the period 1919–30 research and test engineer as well as educational director for the Narragansett Electric Lighting Company of Providence, R. I., now has received his appointment as instructor in electrical engineering at the Rhode Island State College, at Kingston, R. I. During the whole of the above mentioned period Mr. Mowbray was serving the New England Section of the National Electric Light Association on its meter committee, of which he for one year was chairman; he also was a member of the A.I.E.E. instruments and measurements committee 1924–29.

L. A. MAGRAW (A'07, M'13) who at a recent conference was chosen to serve as president of the National Electric Light Association's Southeastern Division, has relinquished the presidency of the South Carolina Power Company, of Charleston, S. C., to become president of the Central Illinois Public Service Company, Chicago, Ill. Mr. Magraw received his degree of B.S. in E.E. from Worcester Polytechnic Institute; his achievements in electrical engineering have been outstanding for over 20 years, most of them having been in the South where he has been active since 1909.

R. E. DOHERTY (M'27) who last year resigned from his many years of service as consulting engineer of the General Electric Company, Schenectady, N. Y., to become professor of electrical engineering at Yale University, New Haven, Conn., continues his chairmanship of the Institute's education committee for the year following August 1, 1932. Mr. Doherty's native State is Illinois; he was graduated from the University of Illinois in 1909, at that time receiving his B.S. degree, and later, in 1921, his M.S. was won from Union College (Schenectady, N. Y.). He entered upon the General Electric Company's training course at Schenectady in 1909 and for 2 years was occupied in its test department. At the end of that time he was transferred to the a-c engineering department as proposition designing engineer. Here his work was observed by C. P. Steinmetz, who in 1920 chose Mr. Doherty as his assistant. It was while engaged in this work that he took his postgraduate course at Union College. The next year he became consulting engineer of the General Electric Company. In addition to duties devolving upon him as consulting engineer he has had charge of an advanced course in engineering specially planned by his company for a small and selected group of college graduates. This, a 3-year course, is practical professional work. He also was

R. E. DOHERTY

a member of the General Electric Company's general education committee. Institute committees upon which Mr. Doherty already has served are: education 1918–19, 1926–28, 1931–32 (chairman); electrophysics 1924–26; power transmission and distribution 1928–29; and technical program 1931–32. He also has served as chairman of the Institute's Schenectady (N. Y.) Section 1926–27. Mr. Doherty's contributions to technical literature have been numerous, both as regards papers of his own preparation and his discussion of those presented by others.

W. P. TAYLOR (A'26) who ever since his graduation from Johns Hopkins University in 1923 has been associated with the Consolidated Gas, Electric Light and Power Company, at Baltimore, Md., was chosen to receive the 1931 A.I.E.E. Middle Eastern District prizes for both best paper and initial paper for his contribution entitled "Locating Power Cable Faults by Means of a Constant-Current Transformer With Short-Circuiting Switch. Mr. Taylor was born at Waterbury, Conn., but practically all his life has been spent in the state of Maryland. Prior to attending Johns Hopkins University, he spent 4 years in study in the grade schools of Stockton, Md.; his graduation from Johns Hopkins in 1923 was with the degree of B.E. in E.E. Immediately thereafter his work with the Consolidated Gas, Electric Light and Power Company of Baltimore started with his assisting in the conducting of tests on all kinds of electrical apparatus in the company's research and test departments. His present work covers chiefly the planning

W. P. TAYLOR

and conducting of tests on electrical appliances. One of the special investigations conducted was an attempt to determine the comparative life of various rubber compounds used as insulation for wire; another a study of power cable fault locating in an effort to eliminate some of the troubles commonly encountered in this field.

R. F. MONGES (A'08) for 35 years district engineer of the San Francisco, Calif., office of the General Electric Company, retired as of June 1932. He is succeeded by W. C. SMITH (A'07, M'26), who has been with the company as transformer sales engineer and Mr. Monges' assistant. Prior to becoming district engineer, Mr. Monges had held office with the company as assistant engineer for 8 years; he also had spent 2 years in the G. E. test department. This was immediately after his graduation from an electrical engineering course which he took at the University of California.

C. E. SMITH (A'32) who during 1930–31 was student engineer for the RCA Victor Company, Inc., at Camden, N. J., working in the company's development and research laboratories, now has achieved the position of electrical engineer for The Radio Air Service Corporation, at Cleveland, Ohio, having been graduated last June from Ohio State University with the degree of M.S. in electrical communication engineering.

W. R. THORSON (A'26) who at one time was superintendent of electrical distribution for the Consumers Power Company, at Hudson, Mich., and later was in the distribution engineering department of that company at Jackson, Mich., now has been made superintendent of public works at Waverly, Ia.

VANNEVAR BUSH (A'15, F'24) who recently became vice-president and dean of engineering at Massachusetts Institute of Technology at Cambridge, Mass. (see

ELECTRICAL ENGINEERING, April 1932, p. 286, for a brief record of Doctor Bush's professional record), recently received reappointment as chairman of the Institute's technical committee on electrophysics. Doctor Bush already has served an unbroken record since 1924 upon this committee; his chairmanship dates from 1931.

VANNEVAR BUSH

G. M. GRIFFITH (A'23) intermittently during the past 6 years has been identified with Latin-American utilities in Cuba, Costa Rica, and Venezuela; now he has returned to Atlanta, Ga., where he was once in the engineering department of the Georgia Railway and Power Company, to open a consulting engineering office of his own.

A. L. ABBOTT (A'06, M'13) engineer of the Society for Electrical Development, New York, N. Y., recently assumed the title of engineer of the uniform legislation department of the National Electrical Manufacturers Association, New York, N. Y.

D. McK. GREER (A'31) who was engineer in the watthourmeter section of the meter engineering department of the Westinghouse Electric and Manufacturing Company, at Newark, N. J., recently became an engineer of the American Instrument Company, in Washington, D. C.

C. A. BROWN (A'23) who has been doing consulting engineering work for the Union Gulf Line, New York, N. Y., now is southeastern sales representative for the De La Vergne Engine Company, in Philadelphia, Pa.

C. M. BURRILL (A'25) has left the position of research engineer with the Rogers-Majestic Corporation, Ltd., Ontario, Can., to return to the RCA Victor Company, Inc., of Camden, N. J., where he will serve in the research division.

J. L. CARR (A'24) for the past year or so salesman for the General Electric Company at Washington, D. C., has joined the Potomac Electric Power Company of that same city according to notice just received at Institute headquarters.

C. I. B. HENNING (A'13) past-president of the Sporting Arms and Ammunition Manufacturers' Institute, New York, N. Y., and a stockholder in various corporations in this field of activity, recently retired from business.

ALFRED RUTTIMAN (A'15) who has been serving the Florence Stove Company of Gardner, Mass., as research engineer, recently became experimental engineer for the Alaska Freezer Company, of Winchendon, Mass.

W. G. WOOLFOLK (M'16) who has been doing consulting engineering work under the name of W. G. Woolfolk and Company, Chicago, Ill., recently became president of the Detroit City Gas Company, at Detroit, Mich.

F. A. DAVIS (M'31) who has been with the Telephone Bond and Share Company, Kansas City, Mo., now has joined the Portsmouth Home Telephone Company, at Portsmouth, Ohio.

E. R. HARTMAN (M'31) who has been associated with the Telephone Bond and Share Company, at Kansas City, Mo., recently joined the Nebraska Continental Telephone Company, at Columbus, Neb.

J. W. HANCOCK (A'10) who is manager of the Appalachian Electric Power Company at Roanoke, Va., has been elected president of the southeastern geographic division of the National Electric Light Association.

W. H. SAMMIS (A'20) of New York, N. Y., recently was elected a director of the Consumers Power Company, Jackson, Mich. Mr. Sammis formerly was located in the general offices of that company at Jackson.

Obituary

THADDEUS REYNOLDS BEAL (A'03) president and general manager of the Central Hudson Gas and Electric Corporation, Poughkeepsie, N. Y., died August 10, 1932, of a heart attack which came upon him while he was at Nantucket, Mass. Mr. Beal was born in New York City, June 1870, and was educated at the College of the City of New York, graduating from its engineering course in 1889. His father, William Beal, was the founder of the original power company in Newburgh, N. Y., and for 12 years, through a series of consolidations of Poughkeepsie, Newburgh, and New York City organizations, Thaddeus Beal found practical experience with the gas and electric business of these cities. The Central Hudson Corporation was a culmination of some of these consolidations, the merging of the Poughkeepsie Power Company and the Newburgh Gas and Electric Company in 1911 forming the nucleus. Of this new firm, formed after the death of his father, Mr. Beal was general manager, as he had been consecutively of the Newburgh Light, Heat, and Power Company and the Poughkeepsie Light, Heat, and Power Company. On the first of January 1927 he became president of a consolidation involving some 65 eastern gas and light concerns. Mr. Beal was a member of the American Gas Institute, the Society of Gas Lighting, the Engineers' Club of New York, Delta Kappa Upsilon, and was on the executive board of the New York Y. M. C. A. He had also served as a naval officer during the Spanish-American War.

WILLIAM RAMSEY HENDRY (A'05) for the past 25 years active in the electrical industry upon the West Coast, and at the time of his death proprietor and manager of the W. R. Hendry Company at Seattle, Wash., died recently at his home in that city. A native of Montreal, Can. (1875), he removed to Tacoma, Wash., in 1892 and engaged with the construction department of the Thompson-Houston Electric Company. Early in 1893 he was transferred to the general repair shop of the General Electric Company in Portland, Ore., but in the fall of the year he returned to Tacoma and entered the high school for a 2-year period. He then became armature winder for the City Park Railway Company, Tacoma, for 2 years, after which he was identified with the Bernard's Bay Mining and Milling Company, Seward City, Alaska, for a year, in charge of the installation and operation of lighting and power machinery. His next affiliation was with the Coney Island and Brooklyn Railroad Company, Brooklyn, N. Y. The latter part of 1900 found him chief electrician for the Merritt Air Brake Company of New York City, a position which he held until his return West in 1902 to work in the construction and operating departments, and later the contracting department, of the Snoqualmie Falls Power Company, Seattle, Wash. His own Company was established in 1911.

GEORGE FRAME FERGUSON (A'15, M'28) late of Arthur D. Riley and Company, Ltd., Auckland, N. Z., where he held the office of consulting and construction engineer, died there recently. Auckland was Mr. Ferguson's birthplace; there too he received his early education at the so-called "state school" and a course in electrical engineering at the local technical college. In 1906 when 20 years of age he came to the United States and engaged with the Commonwealth Edison Company of Chicago, Ill., remaining there until 1910. Returning to New Zealand, the period from 1911 to 1925 was spent in various hydroelectric undertakings as assistant engineer on the Horo Hora development, the Lake Coleridge works, in the government's hydroelectric department at Tasmania, in charge of high tension design and construction, and with the Southland Power Board on hydroelectric works and distribution. He then returned to Auckland to become manager of the electrical department of Arthur D. Riley and Company, Ltd., representing Ferranti, Ltd., the Telegraph Condenser Company, the Electric Construction Company, and others, carrying out some of the largest

contracts in New Zealand, where he was recognized as a capable member of his profession. He was an associate member of the Institution of Electrical Engineering, London, Eng., and a chartered, registered electrical engineer.

H. O. SWOBODA (A'14, M'27) consulting electrical and mechanical engineer at Pittsburgh, Pa., and president and treasurer of H. O. Swoboda, Inc., died June 30, 1932, in the Pennsylvania Hospital of that city after a short illness. Mr. Swoboda was born in Buchholz, Saxony, Germany, February 4, 1870, and received both his primary and early technical training abroad. He was a graduate of the technical university at Darmstadt, Germany. From 1890 to 1892 he was employed by Siemens and Halske, Berlin, Germany, as electrical engineer. He then came to the United States and joined the General Incandescent Arc Light Company of New York, N. Y., as chief electrical engineer and general superintendent. From 1899 to 1902 he held a similar position with The Falcon Electric and Manufacturing Company; from 1902 to 1907 he was employed by the H. O. S. Engineering Company, at Newark, N. J.; dating from 1908 he was for 2 years consulting electrical and mechanical engineer in New York City. In 1910 he joined the Westinghouse Electric and Manufacturing Company at East Pittsburgh, as assistant superintendent, but in 1912, returned to his consulting work, establishing his own office in the city of Pittsburgh. Mr. Swoboda also has been a liberal contributor to scientific and technical literature. He was a registered professional engineer of the state of Pennsylvania, and his memberships included The American Society of Mechanical Engineers, the German technical society Technischer Verein, and the American Society for Steel Treating. His social activities embraced those of the Lincoln Club of Pittsburgh and the Pittsburgh Athletic Association.

RUDOLPH ROSENSTENGEL (A'05) professor of electrical engineering at Gettysburg College, Gettysburg, Pa., died suddenly August 1, 1932, as the result of an embolism. He was 61 years of age and was born in St. Louis, Mo. In 1894 he was graduated from an electrical engineering course at the University of Wisconsin, his earlier education having been acquired in the public schools of Madison, Wis. For 2 years after leaving college, Mr. Rosenstengel was with the Christensen Engineering Company of Milwaukee in the capacity of draftsman; later he also performed 2 years of similar work for N. A. Christensen, also of Milwaukee, still later spending a period of 8 months in the design of several small electric motors in connection with these same interests. He then joined the Brodessor Elevator Manufacturing Company, but a year and a half later severed this connection to identify himself with the Mechanical Appliance Company of Milwaukee. In September of the year 1905 he was chosen as instructor in mechanical engineering at the Michigan Agricultural College.

Local Meetings

Future Section Meetings

Dallas

September 19—Buffet supper at University Club. REPORT OF SUMMER CONVENTION, by O. S. Hockaday, delegate. TRIBUTE TO VICE-PRESIDENT G. A. MILLS AND DIRECTOR B. D. HULL, by J. B. Thomas. Response by Messrs. Mills and Hull.

Lehigh Valley

October 1—Inspection trip through the Reading Railway electrification at Philadelphia.

Past Section Meetings

Mexico

POWER SALES AND THE ENGINEER, by J. M. Zilboorg, Cia Hidroelectrica Guanajuatense. E. F. Lopez, chmn., gave a report of the summer convention held at Cleveland, Ohio. Dinner. July 21. Att. 22.

Montana

Business meeting. July 19. Att. 6.

Niagara Frontier

Executive committee meeting. July 25. Att. 10.

Past Branch Meetings

Drexel Institute

WIND POWER GENERATING STATIONS, by F. P. States, student. July 20. Att. 9.

FIXED RATIO SYNCHRONOUS FREQUENCY CONVERTERS, by S. I. Croney. August 3. Att. 9.

University of Louisville

ATOMIC ENERGY, by R. B. Craig, student. NEW TYPE ELECTRIC CLOCK, by L. B. Bryan; student.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

GRAD. E.E., 29; 5 yr. supervisory construction, design, estimating and field engg. experience on super-pwr. plants and substations; 4 yr. industrial power plant operation, elec. construction and maintenance experience; ry. electrification constr. experience. C-4428.

EXPERIENCED ELECTRICIAN. Col. grad. Wide experience in all branches of elec. installation and service including radio and photoelectricity, desires connection with movie studio. Location and salary no object. D-1309.

E.E. GRAD., 1928, U. of Kansas, 27, married, $2^1/_2$ yr. technical experience in telephone pole line constr. and maintenance with Am. Tel. & Tel. Co. Six months experience as city engr., 2 yr. experience in highway engg. and reinforced concrete design and construction. Available immediately, location, immaterial. D-1342.

OUTSIDE PLANT ENGR., 27, single, B.S. in E.E. from Sheffield Scientific Sch. in 1927. One yr. experience in testing d-c ry. car lighting equip., 4 yr. design and application of pole line and underground hardware for telephone plant. D-1305.

Design and Development

ENGR., 31; 12 yr. Bell system and govt. plant and field experience on sound picture, radio and telephone (manual, dial, repeater and carrier current) systems. Design and devpt. of manual and automatic elec. testing equip. Industrial applications of electron tubes. Available immediately. C-9376.

REFRIGERATION ENGR., 33, married, A.B., E.E., also member Phi Beta Kappa and Sigma Xi. Extensive experience in designing Ranco thermostatic relays, $1^1/_2$ yr. experience in study and design of humidity and room temperature control apparatus. Desires work with refrigerator mfr., or co. in air-conditioning field. Best of references. D-1310.

DEVPT. AND DESIGN ENGR., B.S., E.E., 35, married; 11 yr. experience elec. construction and design, also devpt., assembly, and testing of oil & gas elec. equip. including engine testing and devpt. of elec. control and engine cooling systems. Can assume full responsibility of devpt. program. Available immediately. Location, immaterial. D-1277.

MECH. AND ELEC. ENGR., inventive, analytical, mature; 30 yr. designing engr. G.E., Crocker Wheeler and Westinghouse. Wide experience in motor control systems and apparatus. Inventions extensively used. Desires devpt. work in same or related fields or as consultant. Salary to suit location and duties. A-2110.

E.E. GRAD., single, 8 yr. switchboard and motor control designing, pricing, specifying, and writing specifications. Qualified designer, estimator, inspector, or genl., resident, operating and consulting engr. Excellent references from 2 elec. mfg. companies. Available immediately. Location, U.S. C-3530.

E.E., 32, col. grad., $8^1/_2$ yr. diversified experience including test and central station engg. with G.E. Co.; design, construction and system devpt. for a large utility; plant engg. with a large industrial concern; also $1^1/_2$ yr. small plant power and refrigeration operation and maintenance. C-5727.

DISTRIBUTION, design, or mfg. engr., E.E. grad., 27, married, 6 yr. experience with Westinghouse on distribution, special and small transformer designs. Desires responsible position as transformer design, devpt. or mfg. engr. of elec. engr. for mfg., utility, holding co., or where knowledge of a big company's methods may be used. Available immediately. D-963.

E.E., univ. grad., elec. pwr. experience, both design work and construction and maintenance work, desires position with pwr. or mfg. organization offering permanent or temp. position in office or field. B-1923.

Executives

INDUSTRIAL AND CENTRAL STATION ENGR., Cornell grad. Married, 15 yr. practical experience on design, installation and operation of manual and automatic elec. control for industrial and central station application. Available Sept. 1. Capable executive. D-1273.

PLANT ENGR., ASST. EXEC., E.E.-M.E. grad., 20 yr. broad experience in and with mech. trades on construction and plant maintenance; in modern design, manufacture and installation of equip.; design and layout of plant. Special training and experience in metallurgy, concrete, elec. arc welding, building constr., specifications, business mgmt., sales. C-4519.

EXEC. ASST. available, E.E. grad., 37; 12 yr. utility experience. Appraisal work of power plants, substations, transmission and distribution systems, rate investigations covering industrial

rvice, residential and commercial, cost studies, atistical research, operation in plant, equip. and nes. G.E. test course. B-9782.

INDUSTRIAL PLANT ELEC. EFFICIENCY XPERT, 36, with steam engg. and elec. engg. iploma and 12 yr. industrial plant experience, esires position with opportunity. Will go anyhere. B-7004.

ELEC. AND CHEM. ENGR., experienced in el. and tel. communication including devpt., mfg., nd operation, 37, married. Can fill any suitable osition requiring initiative, wide experience, and a rge acquaintanceship in the communication indusy. C-1971.

E.E. GRAD., 38; 17 yr. experience, construcon, installation, maintenance, inspections, tests, wr. plants and substations, distribution (high and w tension), 1 yr. operating, familiar with So. m., speaks several languages. Available at once, ome or abroad. Best of references. C-2021.

E.E. GRAD., 46, married. G.E. test followed y 20 yr. experience in transformer design and anufacture with the large companies. Desires onnection with elec. mfr. or pwr. co. Available n short notice. C-8806.

E.E., M.I.T.; 1921; Columbia Univ.; 32, arried. Engr., consultant, editor, tech. sales ep. Broad exper., U.S., Canada, communication pparatus, circuits; telephone, telegraph; voice, arrier, radio frequency; amplifiers, sound pictures, rogram transmission. Built, directed electrocoustic testing lab. Experience, employment; atent consideration, court testimony; magazine, ewspaper publishing; lecturing; publicity. Prer New York. D-1315.

E.E., B.S. in E.E., Iowa St. Col. 1929; 32, single, orked way through col. 3 yr. group leader, Vestinghouse transformer test, including power, istr.; and instrument transformers, a-c welding utfits, special apparatus. Liberal shop experince. Interested, exec. position, supervision, esign, and constr.; inspection and testing. Refernces. Location immaterial. Available immeditely. D-1081.

E.E., univ. grad., pwr. experience, desires position ith pwr. or mfg. co. Devpt. work preferred, but ot essential. B-1923.

E.E., 20 yr. experience in design, maintenance, nd construction of central and substations; equip. f buildings and industrial plants, desires a connecon with utility or factory. Specialized work, in rotective circuits, metering problems; automatic lec. control of conveyors, substations, condensers, nd combustion systems for boilers. B-7290.

ENGR.-ACCOUNTANT. E. E. deg., 1912, pecial study in accounting, exec. experience, 10 yr. ith pub. serv. commission and 7 yr. mgmt. corp. aking appraisals, audits, rate studies, and investiations all classes utilities both U.S. and Latin merica. Available soon. C-2569.

nspection

GRAD. E.E., 1927, single, 3 yr. experience as nspection engr. and supervisor; 1 yr. of meter esting. Location in the East. Available imediately. C-3213.

nstruction

M.E.; M.S., 26, single. Four yr. experience in elephone work. Desires teaching or engg. work of ny nature except sales. Available immediately. ocation, immaterial. D-1225.

GRAD. E.E., 7 yr. teaching, 18 yr. practical xperience. Last 12 yr. in mechanical lines; eam, gas, air, and water engg., ore and alkali plants, handling, conveying, and process equp. Taught heat pwr. engg. at Oregon St. Col. and elec. lab. at Beaune, France. Location, immaterial. A-3651.

E.E. GRAD., 1930, 27, single. Fourteen months G.E. test. Five months assignment in G.E. research lab. Experience also includes teaching E.E. subjects for 7 months. Desires position as instructor in E.E. subjects or physics with opportunity of taking grad. work. D-136.

PROFESSOR, B.S. (E.E.), M.S., and E.E. deg., Colorado and Cornell, 38, 9 yr. experience teaching elec. engg. subjects and engg. physics, 9 yr. practical experience in varied fields. Available for Sept. D-1351.

INSTRUCTOR, elec. lab. and trade training, grad. Lowell Inst. auspices M.I.T., elec. and industrial mgmt. courses, Mass. and Conn. teacher's certificate, 44, married. Twenty yr. elec. utility operating experience, maintenance electrician, contracting, secy. Elec. Lines Club, chairman meeting and papers committee, Mass. Assn. Municipal Elec. Inspectors. C-8411.

PHYSICIST, 49, married., Ph.D. Seven yr. univ. teaching experience, Yale, U. of Ill.; 1 yr. study, Rutherford, England. Fifteen yr. experience, directing, carrying on research in heat transmission and phases elec. and mech. lines 2 large industrial concerns. Present position being discontinued. Desires position of responsibility, univ. teaching or in industrial research. D-1366.

E.E. GRAD., 26, single, excellent physical condition. One yr. experience installation, testing telephone exchange equip. Three yr. teaching pub. sch. Grad. small bus. col. Considerable training, experience, selling. Not afraid of hard work. Interested in position requiring engg. knowledge or teaching experience. Excellent references. Correspondence invited. Location, immaterial. Available immediately. D-1076.

E.E., married, good health and strong physique, M.S. in E.E. 1932 with thesis on mercury tube voltage regulator, 3 yr. teaching engg. drawing and descriptive geometry in large univ., clever in adjustment and repair of mech. and elec. devices, machinist experience. Westinghouse grad. student. Prefers teaching position, but anything considered. D-445.

MECH.-ELEC. ENGR., 32, 4 yr. Cornell design instructor; 5 yr. Allis-Chalmers design; liberal shop experience; 5 yr. cooperative apprenticeship. Will consider anything, anywhere, now available. Salary open. D-122.

Junior Engineers

E.E. GRAD., U. of Pittsburgh, 1932, single, 27. Five yr. various elec. experience including wiring, radio, substation operation and maintenance, experience on oil circuit breakers, and several months' experience testing pwr. relays. Prefers position with utility. D-1249.

GRAD. E.E., 29, single. Desires connection with constr., utility, mfg. or holding co. Five yr. experience designing both a-c and d-c motors with large elec. mfg. co. Aggressive and capable of assuming responsibility. Excellent references. Available immediately. D-944.

RECENT RENSSELAER POLY. INST. GRAD., E.E., 1932; Sigma Xi; single; 22. Summer experience in engg. and standardization dept. of large mfg. concern. Desires work in any engg. field. Salary and location secondary. Available immediately. D-1296.

B.S. in E.E., 1931, Armour Tech., 23, single, experience, 6 mos. telephone, 3 mos. G.E. Co. student, 7 mos. utility co. student. Speaks German well, wants work. Salary secondary. Location, immaterial. D-1072.

GRAD. E.E., B.S., A.B. from a foreign univ., desires position with a mfg. co. or a utility in transmission, distribution or testing lab. or elec. ry. Available on short notice. Location, immaterial. D-1110.

E.E. GRAD., '32. Married, 24. Experience includes 6 months asst. radio engr. at broadcast station, amateur 3 yr., 6 months auto. mech. Holds radio broadcast and amateur licenses. Very good references. D-1360.

E.E. GRAD., 1932, Mississippi St. Col., single, 30, excellent health. Two yr. marine electrician, U.S. Navy; 2 yr. engr. and operator local lt. and heat plant, Union Univ., Jackson, Tenn.; illumination experience. Desires position with future. Available immediately—anywhere, South or West preferable. D-1269.

B.S. in E.E. 1932. Ohio Univ., 22, single. Desires position with utility or mfg. concern. Wiring and repair experience. Particularly interested in work with motors and generators. Available immediately. Location, immaterial. D-1280.

B.S. in E.E., 1931 grad., single, 24, desires position in elec. engg. preferably teaching or research. Two summers' experience with elec. contracting co. Was grad. asst. at col. this yr. High scholastic record. References. Salary and location secondary. Available immediately. D-1259.

E.E., 27, single, available Nov. for responsible position abroad, British West Indies preferred. Eight yr. practical experience in large Canadian repair shop handling all types pwr. equip. Three yr. executive and sales. Able to take charge repair dept. industrial concern or pwr. co. Knowledge of industrial engg. Excellent references. C-8336.

B.S. IN E.E. 1932, 23, single. Five yr. cooperative course, 18 mos. experience with telephone and pwr. co. Winner first award South Eastern A.I.E.E. convention. Salary immaterial at start Available at once, location, U.S. D-1304.

B.S. IN E.E., New York Univ., 1932, single, 21, member Tau Beta Pi. One summer's experience in test dept. United Electric Lt. & Pwr. Co. Industrious, intelligent worker who can take and give orders in right manner. Location, salary immaterial factors. C-9434.

E.E. GRAD., '28, B.S. '27. Four yr. with large mfg. concern. Special training in engg. fundamentals (elec. and mech.) as preparation for devpt. work. Desires position with mfg. concern, utility, teaching or as asst. to consultant. D-1290.

E.E. GRAD., 1931, Mid-West univ., 25, single, 2 yr. experience with elec. contracting and constr. co. Desires position in the illuminating field. Location, immaterial and available immediately. D-1365.

E.E. GRAD., Purdue, 1930. Single, 24. Two yr. communication experience and training with Am. Tel & Tel. Co., including outside line and cable construction; test room operation, carrier systems, etc., also Morse telegraphy. Not afraid of hard work. References gladly furnished. Available immediately to go anywhere. D-1075.

E.E. GRAD., 29, married. Five yr. with Western Elec. Co. Experience most valuable for communication engg., but also desires work in research lab. or any engg. field. Good scholastic record. Available anywhere on short notice but East preferred. D-1323.

M.S. in E.E., 1932, 22, single. Technical experience with X-ray and glow discharge tubes. Desires position in teaching or engg. field. Salary and location immaterial. Available after Sept. 10. D-1375.

B.S. in E.E., 1932. Married. Some experience in surveying. Location, immaterial. Prefer work in elec. field but will consider anything. Available immediately. D-1373.

B.S. in E.E., 1932, 22, single. Good references, desires engg. work with future. Location, immaterial. Available at once. D-1374.

Maintenance & Operation

FOREMAN, 37, single, desire foreign or domestic connection involving constr., operation or maintenance (elec.) or pwr. houses, substations or industrial installations of all voltages and capacities. Has had $3^1/_2$ yr. experience in Latin America with Am. holding co. Available now. Location, immaterial. D-1343-328-C-1-San Francisco.

ELEC. MAINTENANCE ENGR.-operator-elec. foreman-inspector-electrician-tech. grad., 30. Twelve yr. experience. All types industrial and mining equipment. Construction and operation of hydroelectric, steam, pwr. plant, outdoor switching stations; transmission lines distribution and telephone systems; elec. ry. Seven yr. Latin America. References. Knowledge Spanish, Portuguese. D-1353.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

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MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Patents

PATENT ENGR., comprehensive experience including preparation patent applications, analysis patents for essential scope, tests marketed products to ascertain infringement, test and testimony in litigation. Familiar, elec., acoustic, wire communication, radio fields. Qualified by basic preparation Ph.D. in physics to do effective work in other engg. branches. Can conduct research if desired. C-4919.

Research

RESEARCH ENGR., B.S. in E.E., Pennsylvania St. Col., 1930; 1½ yr. experience as statistician-research engr. on industrial and marketing surveys. Can speak Spanish fluently. C-7551.

INVENTOR, just completed invention of office machine of cash register type desires income. Exceptionally qualified for inventive, design or research work and has widely varied experience including automobiles, elec. equip., and utilities. Education, E.E. and business administration. G.E. test. No better or harder worker can be found. Any location. C-9820.

E.E., M.S. '29, Ph.D., Calif. Inst. Tech. '32. Research work dealt with measurement lighting currents, use high and low frequencies and surges in dehydration of crude oil emulsions, and cracking of gasolines. Two yr. experience, electrician, pwr. plant test engr. Desires position, where experience, and training will be useful. Single, 28. D-1350.

E.E. GRAD., '23 Sc.M., M.I.T. and Harvard '28; Sc.D. M.I.T. June '32; 38, single; 9 yr. practical experience, pwr.-and-communication engg. Two yr. testing course. Speaks Swedish, English, German; reading knowledge French. Desires position preferably in line of communication engg. Available. Location, immaterial. D-747.

PUB. UTILITY RESEARCH; U. of Ill. grad., 36, married. Twelve yr. experience consulting field charge of transit and street traffic operating surveys, pwr. and other utility rate, regulation, franchise, valuation, and financing investigations, most principal eastern, mid-west and southern cities. Open to either permanent or good temporary assignment. B-446.

MEDICALLY INCLINED 1930 E.E. grad., industrial experience, desires elec. work, hospital, medical school or research lab. where experimental or practical work is being done in applied elec. Studied electrotherapeutics past year. Salary secondary to opportunity to study this special application of electricity. Intends taking academic work in this field. C-9497.

E.E. GRAD., Bucknell 1928. Single, 26. One yr. experience research dept., of large engg. corp., 3 yr. experience and training with Am. Tel & Tel. Co. including outside line and cable constr. and testing methods; also familiar test room operation and methods. Excellent references. Available immediately. Location, immaterial. C-4528.

Sales

SALES ENGR., E.E. deg., 30, single, 3½ yr. high grade sales experience selling industrials and educational institutions, contacting distributors branches, etc. Good correspondent. 1½ yr. engg. dept. large utility. 1½ yr. elec. testing lab. Some elec. contracting. Desires position of promise with mfg. concern. Mid-West preferred, not essential. Available one month. D-1344.

ASSOC. A.I.E.E., single, 26, E.E. Grad. J. H. U. Experience: 6 mos. switchgear testing; 3½ yr. as motor control engr., including shop, engg., and sales work; 6 mos. as jobbers' salesman. Familiar with industrial control design, application, and estimating. Desires any engg. position with opportunity. East preferred, not essential. D-1368.

GRAD. E.E., 1926, Columbia, 29, married. Practical experience with pwr. and telephone companies. One yr. lab. asst. in elec. classes and 4 yr. instructor in evening classes in col. mathematics. Engg. sales experience. C-9308.

E.E. GRAD., 29, single. Seven yr. with elec. utilities covering distribution planning, operation, customer contacts, etc. Substation design, equip. recommendations, voltage studies, relay setting. Eighteen months' experience changing system from 30 to 60 cycles, involving industrial electrification; covering uses of electricity. Can write reports. Suited for pwr. sales work. Available immediately. C-5960.

B.S. IN E.E., Professional Engr., N. J., 34, married. Storage battery, automotive elec. sales and service, 5 yr. heat and sound insulation sales engg. contacting architects, engineers, job supervising, 4 yr. steel corp. sales engr. contacting architects, engr., New York, New Jersey, 3 yr. inventive ability and experience. C-75.

NATURAL GAS HEATING, VENTILATING, AND APPLIANCE ENGR., 27, grad. B.S. in E.E. Two yr. experience in design, installation, and maintenance of gas heating plants. Formerly on sales engg. staff of western utility. Available immediately. C-9525.

SALES ENGR., single, grad. E.E.; 7 yr. experience selling elec. equip. (motors, generators, etc.) to industrial plants located in the East and Mid-West territories and 13 yr. connection with large utilities in industrial sales work and as supervisor of pwr. sales dept. C-5546.

GRAD. ENGR., 25, 2 yr. practical work, research and testing. Capable of speaking, reading and writing Spanish fluently. Available at once, willing to travel if necessary. Class of 1930. Willing to study under sales engr. as applicant has 2 yr. selling experience. C-9002.

Membership

Recommended for Transfer

The Board of Examiners, at its meeting of July 27, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary.

To Grade of Fellow

Dates, Henry B., prof. of e. e., Case Sch. of Ap. Sci., Cleveland.
Dows, Chester L., head elec. and photometric measurements, Genl. Elec. Co., Cleveland.
Enfield, Wm. L., mgr., Incandescent Lamp Dept., Genl. Elec. Co., Cleveland.
Jansky, Cyril M., prof. of e. e., Univ. of Wisconsin, Madison.
Lincoln, John C., chmn. of board, Lincoln Elec. Co., Cleveland.
McMillan, Fred O., research prof. of e. e., Oregon State Col., Corvallis.

To Grade of Member

Berry, Henry P., preliminary plans engr., Chesapeake & Potomac Tel. Co., Charleston, W. Va.
Bolsterli, Arthur A., elec. engr., Safety Car Heating & Lighting Co., New Haven, Conn.
Carville, Ellsworth M., small motor design engr., Westinghouse E. & M. Co., Springfield, Mass.
Charest, J. C., supt. of distribution, Pa. Pwr. & Lt. Co., Hazleton.
Clark, Sam W., engr. and supt. of pwr. plant construction, Calle Gante No. 15, Mexico, D. F.
Congleton, Ray T., proprietor, Congleton Engg. Co., Dayton, O.
Crymble, Alfred C., pres., Crymble Elec. Co., Inc., Bristol, Va.
Del'Homme, Laurence, asst. engr., Houston Ltg. & Pwr. Co., Texas
Eide, Randolph, pres., Ohio Bell Tel. Co., Cleveland.
Frazier, Richard H., asst. prof. of e. e., Mass. Inst. of Tech., Cambridge.
Gill, Peter Clark, supt. of trans. and distribution, B. C. Elec. Ry. Co., Vancouver, B. C.
Harrington, Charles A., e. e. dept., Cleveland Elec. Ill. Co., Ohio.
Hattingh, Johannes T., tech. asst. to chmn. of electricity supply commission, Johannesburg, S. Africa.
Hibshman, Nelson S., asst. prof. of e. e., Lehigh Univ., Bethlehem, Pa.
Hill, Owen E., supervising devpmt. engr., Western Elec. Co., Inc., N. Y. City.
Hover, Ernest W., design engr., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Jansky, C. Moreau, Jr., consulting radio engr., Jansky & Bailey, Washington, D. C.
Keiffer, Lawrence R., elec. engr., Genl. Elec. Co., Cleveland, O.
Kubiak, Henry J., instructor in e. e., Univ. of Wisconsin, Madison.
Mason, H. Russell, prof. of e. e., Southwestern Louisiana Inst., Lafayette.
Payne, John H., elec. engr., East Orange, N. J.
Pearson, Harold E., switchgear commercial engr., Genl. Elec. Co., Phila., Pa.
Porter, Vance C., dist. mgr., Central Pwr. & Lt. Co., Bay City, Texas.
Ranson, Richard R., elec. engr., Cutler Hammer, Inc., Milwaukee, Wis.
Schnautz, Wm. J., outside plant engr., N. Y. Tel. Co., Buffalo, N. Y.
Spring, Ernest W., research engr., Detroit Edison Co., Mich.
Staehle, Daniel, Jr., elec. engr., Frank Adam Elec. Co., St. Louis, Mo.
Stine, Wilmer E., research and welding engr., Lincoln Elec. Co., Cleveland, O.
Wilson, Archibald F., asst. vice-pres., Ohio Bell Tel. Co., Cleveland.
Youngstrom, N. C., member tech. staff, Bell Tel. Labs., Inc., New York.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Sept. 30, 1932.

Berthold, R. V., Assonet Beach, Mass.
Busby, T. A., The Commonwealth & Southern Corp., Birmingham, Ala.
Hanson, V. A., (Member) Mechanical Pwr. Engg. Associates, Bklyn., N. Y.
Hatto, S. G., Shell Oil Co., Seattle, Wash.
Izzi, V. A., Bd. of Transportation, City of N. Y., N. Y.
Kendall, Ralph M. (Member), Amer. Tel. & Tel. Co., 195 Bway., N. Y. City.
Miller, H. E., (Member) Westinghouse Elec. & Mfg. Co., Newark, N. J.
Mitchell, S. R., 1840 Lincoln St., Denver, Colo.
Niemann, A. W., Bell Tel. Lab., Inc., N. Y. City
Olsen, W. O., 1054 52nd St., Bklyn., N. Y.
Spiegel, W. F., Ry. Express Agency, Inc., Hoboken, N. J.
Stone, M., Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
Strothman, R. A., 7 Laurel Ave., Summit, N. J.
Thicke, J. E., Aluminum Co. of Canada, Montreal, Quebec.
Turner, C. G., Kansas City Pwr. & Lt. Co., Mo.
15 Domestic

Foreign

Alizo C., Antonio, Cia. Annma. Planta Elect. de Valera, Est. Trujillo, Venezuela, S. A.
Beljabsky, A. G., (Member) North-Caucas Inst. of Energetics, Novocherkassk, U.S.S.R.
Bryant, A., Kenya & Uganda Govts., Nairobi, Kenya Colony, E. Africa.
Chan, S., 33 Wan Tsai Rd., Hong Kong, China.
Foulsum. W. C., 16 Bondoran Parade, Mont Albert, Melbourne, Australia.
Kesavan, V. K., Pwr. Station Kottayam, Travancore, So. India.
Rozario, J. F. T., Pub. Wks. Dept., Madras Govt., Madras, India.
Thampan, K. C., Pykara Construction Wks., Glen Morgan P. O., The Nilgiris, So. India.
Verma, R. P., Gaya Engg. & Elec. Pwr. Sup. Co., Ltd., Gaya, India.
9 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Adams, Albert J., 950—18th Ave., Honolulu, T. H.
Blugerman, L. N., 227 N. 18th St., Phila., Pa.
Callen, R. J., Brunswick Recording Lab., 799—7th Ave., N. Y. City.
Cooper, Lamar S., 1936 Dallas St., Phila., Pa.
Dalas, F. L., Boulder City, Nev.
Deney, Roger W., 685 Sumner-Atlantic Ave., Forest Hills Boro, Pittsburgh, Pa.
Diamond, Harvey, Avenida Concepcion 105, Providencia, Santiago de Chile, S. Am.
Gooding, Chas. C., 1414 K St., Sacramento, Calif.
Keiser, Morris, 1025 King St., Alexandria, Va.
Morita, Kadzuo, c/o Chosen Hydro-Elec. Co., Kankyo-Nando, Korea, Japan.
Neander, M., 182 Pravy Bereg Nevy Kv. 51, Leningrad, U.S.S.R.
Nichols, E. D., 536 W. 3rd St., Erie, Pa.
Olsson, Oscar G., 361 Mulberry St., Williamsport, Pa.
Pearson, Ernest, 209 Brewster Rd., Scarsdale, N. Y.
Schroeder, G., Krivokolenni Pereulok No. 11–16, Moscow, U.S.S.R.

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during July are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

PLANNING FOR RESIDENTIAL DISTRICTS. Ed. by J. M. Gries and J. Ford. President's Conference on Home Building and Home Ownership, Washington, D. C., 1932. 227 p., illus., cloth, $1.00.—The final reports of 4 committees of the President's Conference on Home Building and Home Ownership; viz., city planning and zoning, subdivision layout, utilities for houses, and landscape planning and planting. This is a compact presentation of principles and practises, most interesting to planning commissions, public officials, civic improvement associations, and home owners. The various committees included well-known specialists in each field, and their findings are the result of wide experience.

REFRIGERATING DATA BOOK AND CATALOG. 1st ed., 1932–1933. Am. Soc. of Refrig. Engrs., N. Y., 1932. 480 p., 120 p., cat. information, illus., 10x6 in., leather, $3.50.—The basic data of refrigeration engineering are brought together in this volume which will be welcomed as a convenient encyclopedia of current practise. The various topics have been treated by specialists with the assistance of an advisory committee appointed by the society. Principles, equipment, and uses all are discussed.

STRESSES IN FRAMED STRUCTURES. Pt. 1. Design of Steel Mill Bldgs. By M. S. Ketchum. N. Y. & Lond., McGraw-Hill, 1932. 217 p., 9x6 in., cloth, $2.50.—This book covers the calculation of the stresses in simple beams, trusses, portals, the transverse bent and the 3-hinged arch, and is intended as a beginning course in the subject; 40 problems which cover the calculation of stresses in practically all types of simple roof and bridge trusses, bents and portals, are solved. Both algebraic and graphic methods of calculation are given. Reprinted from the author's "Design of Steel Mill Buildings."

SUPERHEAT ENGINEERING DATA. 7th rev. ed. N. Y. & Chic., Superheater Co., 1932. 253 p., illus., 7x5 in., leather, $1.00.—A useful collection of rules, formulas, numerical data, and other information frequently wanted by steam engineers and power plant operatives interested in superheating. In addition to the general data, the products of the publisher are described and their use illustrated by a variety of typical installations.

TEXTBOOK OF ELECTRICAL ENGINEERING, 1931. London, H. M. S. O., may be purchased in U.S. from British Library of Information, N. Y. 545 p., illus., 9x6 in., cloth, $2.88.—Prepared for engineer officers of the British army in its electrical service. The generation, transmission, distribution, and utilization of electricity are discussed in a thoroughly practical way, with special reference to the needs of military encampments, barracks, etc. The entire range of electrical work is covered in a severely practical manner. A book which seems well adapted for its purpose.

THEORY OF DIELECTRICS. By A. Schwaiger, transl. by R. W. Sorenson. N. Y., John Wiley & Sons, 1932. 480 p., illus., 9x6 in., cloth, $6.50.—This translation of the second edition of "Elektrische Festigkeitslehre" is intended to fill the needs of engineers and students in search of a comprehensive, readily understandable presentation of the laws of dielectrics. The book is divided into 3 parts, devoted to puncture, arcover, and the practical applications of high-voltage engineering. In addition to reviewing the work of others, considerable original work is included. Includes a list of references to other German publications.

UNIT PROCESSES AND PRINCIPLES OF CHEMICAL ENGINEERING. By J. C. Olsen. N. Y., D. Van Nostrand Co., 1932. 558 p., illus. 9x6 in., cloth, $5.00.—In preparing this textbook, the author has endeavored to present the fundamental chemical and physical principles determining the course of any given chemical reaction, the so-called unit processes which must be utilized in carrying it out upon a commercial scale, and the combination of these processes in proper sequence and coordination. The processes selected for treatment are the most important and most fully developed ones. Each chapter is by a specialist. An excellent introduction to chemical engineering.

WESTERN AND ATLANTIC R. R. OF THE STATE OF GEORGIA. Compiled by J. H. Johnston. Atlanta, Ga., Pub. Serv. Com., 1932. 364 p., illus., 9x6 in., leather, $5.00.—This volume traces the history of a state-owned railroad from its inception to the present day and describes its varying fortunes under state operation and in the hands of successive lessees. The volume is based upon official records and primarily is intended to supply legislators of Georgia with a convenient record of essential facts. It is also an interesting addition to the history of American railroads.

ALLGEMEINE UND TECHNISCHE ELEKTROMETALLURGIE. By R. Müller. Vienna, J. Springer, 1932. 580 p., illus., 9x6 in., cloth, 32.50 rm.—This work is to provide in one volume a concise yet thorough treatise on electrometallurgy and the electrochemical properties of metals, emphasizing commercial methods of production, but noting others briefly. Admirable as a good survey of current methods, with abundant references to literature and important patents.

ATM ARCHIV FÜR TECHNISCHES MESSEN. Lieferungen 4–12, Nov. 1931–June 1932. München und Berlin, R. Oldenbourg. Illus., 12x9 in., paper, 1.50 rm. each.—A compendium of measuring instruments and methods, intended to cover in 5 vols. the whole tech. measurement field. Parts issued monthly and sold singly, each with a 2- to 4-p. review of some dozen instruments or methods and giving ref. to orig. sources. Classified by the Decimal System and a special system, and arranged for loose-leaf binding.

AUSGEWÄHLTE SCHWEISSKONSTRUKTIONEN, Bd. 3. Rohrleitungs- und Behälterbau. By Holler and A. D. Fink. Berlin, VDI-Verlag, 1932. 88 p., illus., 12x9 in., cloth, 12.50 rm.—A set of 88 plates on the application of modern welding for container and pipe line construction. They present a wide variety of apparatus selected to show the advantages of welded equipment for chemical factories, steam plants, etc. Explanations in English.

ÉLECTRICITÉ ET MAGNÉTISME (MEMENTO D' ÉLECTROTECHNIQUE, v. 1). By A. Curchod. Paris, Dunod, 1932. 526 p., illus., 8x5 in., cloth, 99 frs.—Latest addition to handbooks on elec. engg. by the editor of "Revue Générale de l'Électricité," and written to provide the practising engr. with a concise and accurate ref. work similar to the well-known Am. and German handbooks. The first of 4 v., it discusses math., units, fundamental laws of electricity and magnetism, measurements and matls. Includes several bibliographies.

ELEKTRISCHE INDUSTRIEÖFEN FÜR WEITERVERARBEITUNG. By V. Paschkis. Berlin, J. Springer, 1932. 305 p., illus., 9x6 in., cloth, 31.50 rm.—Intended to present a systematic, comprehensive work on the elec. furnace to meet the needs of designers and users. The principles of design, methods of regulation, matls., and the economics of elec. furnaces are considered. Various constructions and their elements are treated at length. Limited to resistance furnaces, explicit directions for design being given.

ELEKTRISCHES KOCHEN. By F. Mörtzsch. Berlin, J. Springer, 1932. 178 p., illus., 10x7 in., cloth, 8.50 rm.—A report of semi-popular style, based upon a series of studies made by elec. plants and elec. mfrs. of Germany, to promote the genl. introduction of elec. cooking and wtr-htg. apparatus for homes, hotels, and institutions. Includes design of efficient apparatus and the finding of proper rates, therefor; also compares elec. heat with other kinds.

GRAPHS FOR ENGINEERS AND ARCHITECTS. By D. H. Lee. Lond., E. & F. N. Spon, Ltd.; N. Y., Spon & Chamberlain, 1932. 88 p., illus., 11x9 in., leath., $2.00.—These graphs treat of a variety of matters in building design and construction and are intended for quick design and checking of calculations. Those for determining safe loads on brick piers and steel, timber, and reinforced-concrete beams, stanchion stresses, wind stresses, panel loads, floor constructions, and similar problems are given and discussed.

INDUSTRIAL MANAGEMENT. By E. C. Robbins and F. E. Folts. N. Y. & Lond., McGraw-Hill, 1932. 757 p., illus., 9x6 in., cloth, $5.00.—Here the "case system" is applied to a beginner's course in industrial management, with 117 cases given to convey concepts underlying modern management; i. e., specialization, diversification, and integration; also their application to managerial control of raw materials, labor, plant, and equipment. To train the student to realize significant facts in managerial problems and to use them basically.

INTRODUCTORY COURSE IN PHYSICAL CHEMISTRY. By W. H. Rodebush and E. K. Rodebush. N. Y., D. Van Nostrand Co., 1932. 421 p., illus., 9x6 in., cloth, $3.75.—A textbook based upon a Univ. of Ill. course; for college Juniors with training in chemistry, physics, and calculus. Fundamental principles are given in a clear, precise manner. The course is designed for a year and presents the material usually included in such courses but with some novel methods and arrangement.

PHYSIKALISCHES HANDWÖRTERBUCH. By A. Berliner and K. Scheel. 2 ed. Berlin, J. Springer, 1932. 1428 p., illus., 11x8 in., paper, 96 rm.—Besides defining terms and concepts of classic and modern physics, this book gives much on astronomy, mathematics, geodesy, geology, physical chemistry, engineering, and other related subjects. It is encyclopedic, with articles signed, and frequent ref. to other information given. Invaluable, especially for those not versed in physics, and for physicists desiring quick orientation in subjects outside their field. The new edition is half again as large as the former.

PRINCIPLES OF REFRIGERATION. By W. H. Motz. 3 ed. Chicago, Nickerson & Collins Co., 1932. 1019 p., illus., 9x6 in., cloth, $7.50.—Giving fundamentals in the operation of refrigerating machinery; the properties of the usual media; design, construction, and operation of the apparatus; also important applications of refrigeration set forth practically and non-mathematically. Adopted by the Natl. Assn. of Practical Refrigeration Engrs. for its national lecture courses. Rewritten and considerably enlarged.

RECENT ADVANCES IN TOWN PLANNING. By T. Adams and others. N. Y., Macmillan Co., 1932. 400 p., illus., 10x7 in., cloth, 25s.—Describing recent advances and tendencies in town planning in its 3 phases of law, practise, and design in an effort toward a comprehensive survey. The point of view is British in its aspect with conditions in Great Britain given special consideration. There is, however, much upon conditions in America and other countries. A book of interest to American town planners. A useful bibliography of books and reports is included.

TEXTBOOK OF METALLURGICAL PROBLEMS. By A. Butts. N. Y. and Lond., McGraw-Hill, 1932. 425 p., illus., 9x6 in., cloth, $4.00.—Resembling "Metallurgical Calculations" by the late Prof. J. W. Richards and somewhat supplementing it, this book extends facts into certain channels also giving new and more accurate numerical data. Its main purpose is to supply a textbook with a graded treatment of the subject, suited for use in engineering courses rather than a handbook for practising engineers. A thorough introduction to problems arising in metallurgy and methods of solving them.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS. 22nd ed., 1931–32. N. Y., Thomas Pub. Co., illus., 12x9 in., cloth, $15.00.—Listing, under products and firm names, Am. mfrs. and primary sources of supply. Trade names, brands, banks, boards of trade, and other commercial organizations, and trade papers are listed. Unequalled in comprehensiveness and completeness.

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N. E. Funk — G. G. Post
W. S. Gorsuch — R. C. Powell
F. C. Hanker — F. A. Scheffler
J. P. Hogan — F. O. Schnure
F. H. Hollister — R. E. B. Sharp
A. H. Hull — A. E. Silver
D. C. Jackson — E. C. Stone — A. R. Smith

Power Transmission and Distribution

P. H. Chase, Chm., Philadelphia Elec. Co., 900 Sansom St., Philadelphia, Pa.

R. N. Conwell, Vice-chm., 80 Park Place, Newark, N. J.

F. E. Andrews — C. R. Higson
G. M. Armbrust — J. P. Jollyman
H. W. Bibber — A. H. Lawton
D. K. Blake — H. L. Melvin
E. S. Bundy — J. S. Parsons
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C. V. Christie — L. L. Perry
W. A. Curry — D. W. Roper
O. G. C. Dahl — H. J. Scholz
A. E. Davison — H. R. Searing
R. D. Evans — A. E. Silver
F. M. Farmer — D. M. Simmons
C. L. Fortescue — C. T. Sinclair
T. H. Haines — L. G. Smith
Edwin Hansson — H. H. Spencer
C. F. Harding — Philip Sporn
K. A. Hawley — W. K. Vanderpoel
L. F. Hickernell — T. A. Worcester — H. S. Warren

Power Applications, General

C. W. Drake, Chm., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A. H. Albrecht — H. A. Maxfield
E. A. Armstrong — John Morse
James Clark, Jr. — N. L. Mortensen
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T. Hibbard — L. D. Rowell
Fraser Jeffrey — L. M. Shadgett
A. E. Knowlton — W. K. Vanderpoel
A. M. MacCutcheon — M. R. Woodward

Protective Devices

R. T. Henry, Chm., Buffalo, Niagara & Eastern Power Corp., Electric Building, Buffalo, N. Y.

Raymond Bailey — H. A. McLaughlin
R. C. Bergvall — D. M. Petty
H. W. Collins — H. J. Scholz
A. W. Copley — H. K. Sels
W. S. Edsall — H. P. Sleeper
J. H. Foote — L. G. Smith
L. E. Frost — E. R. Stauffacher
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S. M. Hamill, Jr. — B. F. Thomas, Jr.
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T. G. Le Clair — E. M. Wood
J. P. McKearin — H. B. Wood

Research

Chester W. Rice, Chm., General Electric Co., Schenectady, N. Y.

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V. Karapetoff — R. J. Wiseman

Transportation

E. L. Moreland, Chm., 31 St. James Ave., Boston, Mass.

H. L. Andrews — H. N. Latey
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Geographical District Executive Committees

District	Chairman (Vice-President, A.I.E.E.)	Secretary (District Secretary)
No. 1—North Eastern	J. Allen Johnson, 302 Electric Building, Buffalo, N. Y.	A. C. Stevens, General Electric Co., Schenectady, N. Y.
No. 2—Middle Eastern	W. B. Kouwenhoven, Johns Hopkins University, Baltimore, Md.	G. S. Diehl, Pennsylvania Water & Power Co., 1611 Lexington Building, Baltimore, Md.
No. 3—New York City	E. B. Meyer, 80 Park Place, Newark, N. J.	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
No. 4—Southern	W. E. Freeman, University of Kentucky, Lexington, Ky.	E. A. Bureau, University of Kentucky, Lexington, Ky.
No. 5—Great Lakes	K. A. Auty, Commonwealth Edison Co., 72 West Adams St., Chicago, Ill.	A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis, Minn.
No. 6—North Central	P. H. Patton, Northwestern Bell Tel. Co., Telephone Building, Omaha, Neb.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. A. Mills, Michigan Gas & Electric Co., Lansing, Mich.	R. W. Warner, University of Kansas, Lawrence, Kans.
No. 8—Pacific	A. W. Copley, Westinghouse Elec. & Mfg. Co., 1 Montgomery St., San Francisco, Calif.	C. E. Baugh, 245 Market St., San Francisco, Calif.
No. 9—North West	C. R. Higson, Utah Power & Light Co., Kearns Building, Salt Lake City, Utah	Paul Ransom, Utah Apex Mining Co., Bingham Canyon, Utah
No. 10—Canada	L. B. Chubbuck, Canadian Westinghouse Co., Hamilton, Ont.	W. L. Amos, Hydro-Elec. Pr. Comm., 190 University Ave., Toronto, Ont.

Note: Each district executive committee includes the chairmen and secretaries of all Sections within the district and the chairman of the district committee on student activities.

Local Sections of the Institute

Name	District	Chairman	Secretary	Secretary's Address
Akron	2	A. P. Regal	W. H. Tucker	716 S. Main St., No. Canton, Ohio
Atlanta	4	O. O. Rae	J. H. Persons	General Electric Co., Atlanta, Ga.
Baltimore	2	J. Wells	J. L. D. Speer	Chesapeake & Potomac Tel. Co., Baltimore, Md.
Birmingham	4			
Boston	1	F. D. Hallock	G. J. Crowdes	Simplex Wire & Cable Co., 66 Sidney St., Cambridge, Mass.
Chicago	5	L. R. Mapes	D. L. Smith	Chicago Rapid Transit Co., Chicago, Ill.
Cincinnati	2	L. O. Dorfman	A. C. Burroway	Cincinnati & Sub. Bell Tel. Co., Cincinnati, Ohio
Cleveland	2	J. M. Smith	S. B. Taylor	Reliance Elec. & Engg. Co., Cleveland, Ohio
Columbus	2	K. Y. Tang	H. L. Willson	General Electric Co., Columbus, Ohio
Connecticut	1	C. J. Daly	W. B. Hall	Yale University, New Haven, Conn.
Dallas	7	H. K. Handley	W. B. Folline	General Electric Co., Dallas, Texas
Denver	6	W. D. Hardaway	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	O. E. Hauser	R. Foulkrod	Michigan Bell Tel. Co., Detroit, Mich.
Erie	2	J. C. Milling	C. V. Roberts	Erie Lighting Co., Erie, Pa.
Florida	4	Joseph Weil	R. P. Smith	P. O. Box 2574, Jacksonville, Fla.
Fort Wayne	5	B. A. Case	C. M. Summers	General Electric Co., Fort Wayne, Inc.
Houston	7	J. B. Arthur	P. H. Robinson	P. O. Box 1286, Houston, Texas
Indianapolis-Laf	5	E. G. Thoms	C. E. Chatfield	711 Illinois Bldg., Indianapolis, Ind.
Iowa	5	L. F. Wood	B. S. Willis	Iowa State College, Ames, Iowa
Ithaca	1	W. E. Meserve	B. K. Northrop	Cornell University, Ithaca, N. Y.
Kansas City	7	G. O. Brown	E. W. Harvey	2124 Wyandotte Ave., Kansas City, Mo.
Lehigh Valley	2	J. G. Charest	W. A. Skinner	Pa. Pwr. & Lt. Co., Hazleton, Pa.
Los Angeles	8	F. E. Dellinger	A. P. Hill	7046 Hollywood Blvd., Hollywood, Calif.
Louisville	4	C. M. Ewing	L. O. Adams	General Electric Co., Louisville, Ky.
Lynn	1	W. K. Dickinson	G. R. Sturtevant	General Electric Co., West Lynn, Mass.
Madison	5	G. F. Tracy	R. E. Johnson	University of Wisconsin, Madison, Wis.
Memphis	4	W. A. Gentry	F. L. Christenbury	Memphis Pwr. & Lt. Co., Memphis, Tenn.
Mexico	3	E. F. Lopez	L. Castro, Jr.	Dept. Elec. y Teleg., Ferrocarilles Nacionales de Mex., Mexico, D. F.
Milwaukee	5	W. F. Lent	C. D. Brown	6309 W. McKinley Ave., Wauwatosa, Wis.
Minnesota	5	H. J. Pierce	R. R. Herrmann	Northern States Pwr. Co., Minneapolis, Minn.
Montana	9	J. A. Thaler	H. Dale Cline	312 South 6th Ave., Bozeman, Montana.
Nebraska	6	Clarence Talsma	H. S. Pahren	724 Union State Bank Bldg., Omaha, Neb.
New York	3	T. F. Barton	W. R. Smith	United Engrs. & Constructors, 80 Park Pl., Newark, N. J.
Niagara Frontier	1	F. S. Wahl	J. F. Oehler	169 Brunswick Blvd., Buffalo, N. Y.
North Carolina	4	J. E. Lear	R. F. Stainback	Univ. of No. Carolina, Box 1029, Chapel Hill, N. C.
Oklahoma City	7	E. B. Jennings	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	Lewis Fussell	J. L. MacBurney	Elec. Storage Battery Co., Philadelphia, Pa.
Pittsburgh	2	Thomas Spooner	R. L. Kirk	Duquesne Light Co., Pittsburgh, Pa.
Pittsfield	1	V. M. Montsinger	S. T. Maunder	General Electric Co., Pittsfield, Mass.

Local Sections of the Institute—Continued

Name	District	Chairman	Secretary	Secretary's Address
Portland, Ore.	9	F. M. Lewis	V. B. Wilfley	Westinghouse Elec. & Mfg. Co., Portland, Ore.
Providence	1	I. W. Knight	R. W. Allen	Narragansett Elec. Co., Providence, R. I.
Rochester	1	C. F. Estwick	L. R. Gillespie	Rochester Tel. Corp., Rochester, N. Y.
St. Louis	7	F. B. Wipperman	S. L. Hilyard	Illinois Pwr. & Lt. Co., East St. Louis, Ill.
San Antonio	7	I. A. Uhr	W. L. Eyres	San Antonio Public Serv. Co., San Antonio, Texas
San Francisco	8	E. F. Maryatt	Roy Wilkins	Pacific Elec. Mfg. Co., San Francisco, Calif.
Saskatchewan	10	N. W. DuBois	A. B. Coward	Light and Power Dept., Regina, Sask., Canada.
Schenectady	1	E. E. Johnson	H. H. Race	General Electric Co., Schenectady, N. Y.
Seattle	9	A. F. Darland	K. L. Howe	Westinghouse Elec. & Mfg. Co., Seattle, Wash.
Sharon	2	A. P. Bender	E. L. Keene	Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Southern Virginia	4	Cecil Gray	E. L. Lockwood	Virginia Public Service Co., Newport News, Va.
Spokane	9	C. F. Norberg	H. B. Tinling	29 Main Street, Spokane, Wash.
Springfield, Mass.	1	Hans Passburg	J. J. Finn	Roland T. Oakes Co., Holyoke, Mass.
Syracuse	1	C. W. Henderson	W. E. Mueller	506 State Tower Bldg., Syracuse, N. Y.
Toledo	2	I. H. Heitkamp	W. M. Campbell	Toledo Edison Co., Toledo, Ohio
Toronto	10	I. M. Maclean	J. M. Thomson	171 John St., Weston, Toronto, Ont., Can.
Urbana	5	E. A. Reid	L. L. Smith	University of Illinois, Urbana, Ill.
Utah	9	A. L. Taylor	E. L. Morris	Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah
Vancouver	10	G. R. Wright	D. M. Johnstone	B. C. Elec. Ry. Co., Ltd., 425 Carrall St., Vancouver, B. C., Can.
Washington	2	T. J. MacKavanagh	E. T. Walker	Bliss Electrical School, Washington, D. C.
Worcester	1	H. A. Maxfield	R. P. Bullen	General Electric Co., Worcester, Mass.
Total 60				

Student Branches of the Institute

Name and Location	District	Counselor
Akron, Univ. of, Akron, Ohio	2	Paul C. Smith
Alabama Poly. Inst., Auburn, Ala	4	
Alabama, Univ. of, University, Ala	4	F. R. Maxwell, Jr.
Arizona, Univ. of, Tucson, Ariz	8	J. C. Clark
Arkansas, Univ. of, Fayetteville, Ark	7	W. B. Stelzner
Armour Inst. of Tech., Chicago, Ill	5	E. H. Freeman
British Col., Univ. of, Vancouver, B. C	10	E. G. Cullwick
Brooklyn, Poly. Inst. of, Brooklyn, N. Y	3	C. C. Whipple
Bucknell Univ., Lewisburg, Pa	2	G. A. Irland
Calif. Inst. of Tech., Pasadena, Calif	8	R. W. Sorensen
Calif., Univ. of, Berkeley, Calif	8	L. E. Reukema
Carnegie Inst. of Tech., Pittsburgh, Pa	2	George Porter
Case Sch. of Ap. Science, Cleveland, Ohio	2	H. B. Dates
Catholic Univ. of America, Washington, D. C	2	T. J. MacKavanagh
Cincinnati, Univ. of, Cincinnati, Ohio	2	W. C. Osterbrock
Clarkson College of Tech., Potsdam, N. Y	1	
Clemson Agri. Col., Clemson College, S. C	4	S. R. Rhodes
Colorado State Agri. Col., Ft. Collins, Colo	6	H. G. Jordan
Colorado, Univ. of, Boulder, Colo	6	W. C. DuVall
Cooper Union, New York, N. Y	3	A. J. B. Fairburn
Cornell University, Ithaca, N. Y	1	E. M. Strong
Denver, Univ. of, Denver, Colo	6	R. E. Nyswander
Detroit, Univ. of, Detroit, Mich	5	H. O. Warner
Drexel Inst., Philadelphia, Pa	2	E. O. Lange
Duke Univ., Durham, N. C	4	W. J. Seeley
Florida, Univ. of, Gainesville, Fla	4	Joseph Weil
Georgia School of Tech., Atlanta, Ga	4	T. W. Fitzgerald
Harvard Univ., Cambridge, Mass	1	C. L. Dawes
Idaho, Univ. of, Moscow, Idaho	9	J. H. Johnson
Illinois, Univ. of, Urbana, Ill	5	C. E. Skroder
Iowa State College, Ames, Iowa	5	F. E. Johnson
Iowa, State Univ. of, Iowa City, Iowa	5	E. B. Kurtz
Kansas State Col., Manhattan, Kansas	7	R. G. Kloeffler
Kansas, Univ. of, Lawrence, Kans	7	D. C. Jackson, Jr.
Kentucky, Univ. of, Lexington, Ky	4	E. A. Bureau
Lafayette College, Easton, Pa	2	L. J. Conover
Lehigh Univ., Bethlehem, Pa.	2	N. S. Hibshman
Lewis Inst., Chicago, Ill	5	F. A. Rogers
Louisiana State Univ., Baton Rouge, La	4	M. B. Voorhies
Louisville, Univ. of, Louisville, Ky	4	J. M. Roberts
Maine, Univ. of, Orono, Maine	1	W. E. Barrows
Marquette Univ., Mailwaukee, Wis	5	
Mass. Inst. of Tech., Cambridge, Mass	1	W. H. Timbie
Mich. Col. of Mining & Tech., Houghton, Mich	5	G. W. Swenson
Michigan State Col., East Lansing, Mich	5	W. A. Murray
Michigan, Univ. of, Ann Arbor, Mich	5	S. S. Attwood
Milwaukee, Sch. of Engg. of, Milwaukee, Wis	5	V. M. Murray
Minnesota, Univ. of, Minneapolis, Minn	5	J. H. Kuhlmann
Mississippi State Col., State College, Miss	4	L. L. Patterson
Missouri Sch. of Mines & Met., Rolla, Mo	7	I. H. Lovett
Missouri, Univ. of, Columbia, Mo	7	M. P. Weinbach
Montana State Col., Bozeman, Mont	9	J. A. Thaler
Nebraska, Univ. of, Lincoln, Neb	6	F. W. Norris
Nevada, Univ. of, Reno, Nevada	8	S. G. Palmer
Newark Col. of Engg., Newark, N. J	3	J. C. Peet
New Hampshire, Univ. of, Durham, N. H	1	L. W. Hitchcock
New Mexico, Univ. of, Albuquerque, N. M	7	F. M. Denton
New York, Col. of the City of, New York, N. Y	3	Harry Baum
New York Univ., Univ. Heights, N. Y	3	H. N. Walker
North Carolina State Col., Raleigh, N. C	4	R. S. Fouraker
North Carolina, Univ. of, Chapel Hill, N. C	4	W. J. Miller
North Dakota Agri. Col., Fargo, N. D	6	H. S. Rush
North Dakota, Univ. of, Grand Forks, N. D	6	H. F. Rice
Northeastern Univ., Boston, 17, Mass	1	W. L. Smith
Notre Dame, Univ. of, Notre Dame, Ind	5	J. A. Caparo
Ohio Northern Univ., Ada, Ohio	2	I. S. Campbell
Ohio State Univ., Columbus, Ohio	2	F. C. Caldwell
Ohio Univ., Athens, Ohio	2	A. A. Atkinson
Oklahoma Agri. & Mech. Col., Stillwater, Okla	7	Albrecht Naeter
Oklahoma, Univ. of, Norman, Okla	7	F. G. Tappan
Oregon State Col., Corvallis, Ore	9	E. C. Starr
Pennsylvania State Col., State College, Pa	2	L. A. Doggett
Pennsylvania, Univ. of, Philadelphia, Pa	2	C. D. Fawcett
Pittsburgh, Univ. of, Pittsburgh, Pa	2	H. E. Dyche
Pratt Inst., Brooklyn, N. Y	3	C. C. Carr
Princeton Univ., Princeton, N. J	2	Malcolm MacLaren
Purdue Univ., Lafayette, Ind	5	A. N. Topping
Rensselaer Poly. Inst., Troy, N. Y	1	F. M. Sebast
Rhode Island State Col., Kingston, R. I	1	Wm. Anderson
Rice Inst., Houston, Texas	7	J. S. Waters
Rose Poly. Inst., Terre Haute, Ind	5	C. C. Knipmeyer
Rutgers Univ., New Brunswick, N. J	3	F. H. Pumphrey
Santa Clara, Univ. of, Santa Clara, Calif	8	E. F. Peterson
South Carolina, Univ. of, Columbia, S. C	4	T. F. Ball
So. Dak. State Sch. of Mines, Rapid City, S. D	6	J. O. Kammerman
South Dakota, Univ. of, Vermillion, S. D	6	C. W. Caldwell
So. California, Univ. of, Los Angeles, Calif	8	N. C. Clark
Southern Methodist Univ., Dallas, Texas	7	H. F. Huffman
Stanford Univ., Stanford, Calif	8	W. B. Kindy
Stevens Inst. of Tech., Hoboken, N. J	3	H. C. Roters
Swarthmore Col., Swarthmore, Pa	2	Lewis Fussell
Syracuse Univ., Syracuse, N. Y	1	C. W. Henderson
Tennessee, Univ. of, Knoxville, Tenn	4	J. G. Tarboux
Texas Agri. & Mech. Col., Col. Station, Texas	7	H. C. Dillingham
Texas Tech. Col., Lubbock, Texas	7	C. V. Bullen
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Utah, Univ. of, Salt Lake City, Utah	9	J. H. Hamilton
Vermont, Univ. of, Burlington, Vt	1	L. P. Dickinson
Virginia Military Inst., Lexington, Va	4	S. W. Anderson
Virginia Poly. Inst., Blacksburg, Va	4	Claudius Lee
Virginia, Univ. of, University, Va	4	W. S. Rodman
Washington, State Col. of, Pullman, Wash	9	O. E. Osburn
Washington Univ., St. Louis, Mo	7	W. L. Upson
Washington, Univ. of, Seattle, Wash	9	J. R. Shuck
West Virginia Univ., Morgantown, W. Va	2	A. H. Forman
Wisconsin, Univ. of, Madison, Wis	5	C. M. Jansky
Worcester Poly. Inst., Worcester, Mass	1	C. D. Knight
Wyoming, Univ. of, Laramie, Wyo	6	G. H. Sechrist
Yale Univ., New Haven, Conn	1	W. B. Hall
Total 109		

At the time of going to press for this issue, the list of student officers was not sufficiently complete to include.

Affiliated Student Society

Brown Engineering Society . . . . Brown Univ., Providence R. I.

Industrial Notes

Westinghouse Employes Exceed Sales Quota.—Final reports of the Westinghouse Employes' sales campaign show a sales total of more than $2,900,000. Every employe was to sell at least one appliance. This average was beaten more than 50 per cent and the volunteers closed over 80 per cent of their prospects.

Electrotrim Appointments.—Announcement has been made by Electrotrim, Inc., Union City, Ind., manufacturers of the newly approved and labeled Electrotrim line of two-wire, non-metallic extension wiring, of the appointment of James S. Mahan as sales manager, and L. E. Fuller as special field representative. Both Mr. Mahan and Mr. Fuller were previously associated with Steel and Tubes, Inc.

New Resistor Company.—The Atlas Resistor Company, specializing in the manufacture of pack-wound tubular resistors, has been formed with headquarters at 423 Broome St., New York. W. A. Merrill, general manager of the organization, was previously associated with F. A. D. Andrea, Inc., and the Polymet Manufacturing Co. W. John Killoch, formerly of the David Killoch Co., is sales manager.

Potential Transformers.—The Allis-Chalmers Mfg. Co., Milwaukee, announces a new line of indoor, oil filled potential transformers, designated type PO, rated 200 va capacity, suitable for accurate metering service or for tripping or relay voltage supply. These are available for 6,900, 11,500 and 13,800 volt service, 60 or 25 cycles and the features of the new line are described as: high safety factor in insulation strength in the primary winding; liberal sized primary porcelain; internal parts cover suspended, facilitating inspection; fixed secondary terminals inclosed in conduit terminal compartment.

New Power Reduction Unit.—The Merkle-Korff Gear Co., Chicago, is producing a small, low priced power reduction unit with a wide range of applications due to its compactness and extreme flexibility. The gears run in grease which is sealed in, insuring positive lubrication and quiet operation. The unit can be supplied in any speed from a motor speed of 3,000 rpm down, either for clock-wise or reverse rotation. The unit is so constructed as to be easily attached to any device or mechanism. Induction or synchronous type motors are used.

Pocket Foot-Candle Meter.—According to the manufacturer, many simplified and new photocell applications with relays and indicating instruments have been made possible through the new Weston Photronic photoelectric cell. The latest of these applications, by the Weston Electrical Instrument Corporation, Newark, N. J., is a pocket size foot-candle meter built especially for salesman's use, calibrated to read directly on three ranges—50, 250, or 500 foot-candles. One cell is used as an adjustable light collector, with readings appearing on a scale 2.36 inches in length. The cell and instrument are housed in a neat, black, moulded case, measuring approximately $3^3/_8$ x 7 x $2^1/_4$ inches.

Oilproof Portable Cable.—In certain types of service, portable cords are subjected to the continual attack of oil resulting in deterioration not only of the outer coverings, but eventually of the insulation. To meet this condition the Okonite Company, of Passaic, N. J., has developed a full line of portable cords and cables having a special outer sheath which is impervious to the destructive acting of oil or grease. This line of cords and cables is called "Oilproof Okocord." As the name implies, the new cord possesses all the good qualities of the Okocord line, plus continued resistance to oil, thus rendering it highly suitable for use around machine shops, garages, refineries, oil wells, etc. Strong sunlight and ozone also have little effect on this cord.

More Capacity for Cables.—Load-carrying capacity of single-conductor lead-covered cable is increased and operating cost of the circuit is decreased by the use of a new split-type insulator which is so designed that it can be installed on a cable in service, without cutting the conductor. The insulator, a General Electric product, consists of two split alloy wiping sleeves and a split molded-compound insulator. The wiping sleeve halves are soldered together at the assembly, and bolted to the insulator. The joints between the wiping sleeve and the halves of the insulator are made permanently oil-tight and vacuum-tight by compressing oil-proof gaskets between the surfaces. When single-conductor cable is used on alternating-current systems, the current flowing in the conductor induces a voltage in the lead sheath. If the sheath forms a continuous circuit, this induced voltage causes current to flow in the sheath, resulting in sheath losses that produce a heating effect, which decreases the load-carrying capacity of the cable. Insertion of sheath insulators in the lead sheath largely reduces such currents and losses. In addition to the new split sheath insulators there are also ones to be placed in the casing of a joint or in the cable sheath at the end of a joint.

Trade Literature

Air Cooled Transformers.—Bulletin 172, 2 pp., loose leaf. Describes Wagner types AA and AC units in sizes 1 to 50 kva, voltages 100 to 600. Applications are outlined. Wagner Electric Corp., 6400 Plymouth St. St. Louis, Mo.

Relays.—Bulletin, 4 pp. Describes "Diamond H" magnetrole relay, applicable in many standard and special applications. It is particularly adapted for motor and light control, time and temperature control, signal equipment, photo-electric cell operation, sign flasher service, etc. Hart Mfg. Co., Hartford, Conn.

Electrolytic Condensers.—Catalog 1-C, 16 pp. Describes electrolytic condensers, molded mica condensers. Solar Mfg. Co., 599 Broadway, New York.

Air Cooled Transformers.—Bulletin GEA 897B, 16 pp. Describes G-E air cooled transformers, types M and D, for reducing voltage, balancing voltage, boosting voltage, insulating circuits and phase changing. General Electric Co., Schenectady, N. Y.

Lifting Magnets.—Bulletin 900, 16 pp. Describes various types of EC & M lifting magnets and illustrates recent improvements made in these products. Photographs of the magnets in use by various industries are also shown. The Electric Controller & Mfg. Co., Cleveland, O.

Welding Electrodes.—Bulletin, 16 pp., entitled "Murex Heavy Mineral Coated Electrodes." Numerous applications of inorganic flux coated welding electrodes are described. The welding of mild steel and boiler plate, stainless steel alloys, manganese steel, high carbon steel, stainless iron, and the building up of railway rail ends, special manganese track work, as well as the repair of castings and heavy parts, is covered. Metal & Thermit Corp., 120 Broadway, New York.

Industrial Rubber Goods.—Condensed Catalog, 24 pp., entitled "Engineering Data, Industrial Rubber Goods," giving a simplified, comprehensive outline of the principal Goodrich rubber products for industrial purposes. Included are tables of rubber transmission belting showing horsepower capacities, minimum pulley diameters, leather belt equivalents and list prices. A table on conveyor belts makes it easy to figure the required sizes and plies of a conveyor belt without using a formula. Rubber hose of various types for industrial purposes is also described. The B. F. Goodrich Co., Akron, O.

Horizontal Bearing Mountings.—Bulletin S, 36 pp. Describes horizontal mountings, Kingsbury thrust bearings and journal bearings, small to medium sizes. These bearing mountings are widely used in high speed centrifugal pumps, horizontal hydroelectric units and similar services. The standard shaft sizes for these mountings vary from 2 in. up to 9 in. and the thrust bearing capacities from under 1,000 lbs to over 50,000 lbs. The bearings are automatically lubricated and may be water-cooled when necessary. They are suitable for speeds up to 3,600 rpm or more, as well as for lower speeds. Dimension lists and capacities of three types of mountings of combined thrust and journal bearings and similar data on mountings for individual journal bearings are included. Kingsbury Machine Works, Inc., 4324 Tackawanna St., Philadelphia, Pa.